HANDBOOK
FOR THE
IDENTIFICATION OF
FOREST INSECTS

CONIFEROUS SCOLYTIDAE

KEY TO THE GENUS *SCOLYTUS*

by

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AN ANNOTATED AND ILLUSTRATED KEY TO THE SPECIES OF THE GENUS *SCOLYTUS* (COLEOPTERA, SCOLYTIDAE) ATTACKING CONIFEROUS TREES OF THE NEARTIC REGION

INTRODUCTION

The genus *Scolytus* is one of the major genera of bark beetles occurring in the neartic region of North America and is one of the four major genera from the standpoint of forest economic importance. In recent years much consideration has been given to the taxonomic reclassification of these economically important genera (*Dendroctonus*, *Ips*, *Pseudohylesinus*, and *Scolytus*); for example, in 1963 the genus *Dendroctonus* was revised by S. L. Wood, in 1965 a revision of the genus *Ips* was completed by G. R. Hopping, and a revision of *Pseudohylesinus* by D. E. Bright is in press. However, the genus *Scolytus* has not been revised since 1934 (M. W. Blackman). The material presented here represents a key based on a revision of the neartic species of *Scolytus* occurring on coniferous trees. This revision will include synonymy, more comprehensive taxonomic descriptions, and listings of collection data. Studies for the revision made possible this preliminary key which is designed primarily for the forest entomologist and forester.

The material presented is the results of data collected over a period of nearly three years. Specimens were borrowed from the California Insect Survey, Berkeley, California; the California Academy of Sciences, San Francisco, California; and the U. S. Forest Service Pacific Southwest Forest and Range Experiment Station, Berkeley, California. To supplement material borrowed from museums, extensive collecting was conducted throughout the Pacific Coast and Rocky Mountain States. Through a ten-week research participation grant made possible by the Smithsonian Institute, Washington D. C., specimens in the National Museum were studied. The type and paratype specimens for many of the species were examined at this time. In addition, specimens in the Canadian National Museum, Ottawa, Canada, and the private collection of S. L. Wood, Brigham Young University, Provo, Utah were studied.

Series of all seventeen species of *Scolytus* occuring on conifers were examined, and each species was correlated with the damage or gallery pattern on the host.

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ECONOMIC IMPORTANCE

Of the seventeen species of *Scolytus* which attack coniferous trees in the neartic region of North America, the majority feed and establish their broods on the limbs and fresh slash of their hosts. Most species account for only sporadic damage and are of little economic importance. This does not preclude the fact that any one of these species is potentially a tree killer if given ideal conditions for a massive population buildup. Their role as associates with the more destructive bark beetles, such as the members of the genus *Dendroctonus*, should also be taken into consideration for a true assesment of their importance.

Two species of the genus cause extensive damage to commercially important timber species in western forests. *S. unispinosus* has been credited with killing young Douglas-fir (*Pseudotsuga menziesii*) from two to six inches in diameter over extensive areas of the Pacific

Northwest (Chamberlin, 1958). This species is also commonly found attacking the tops and larger limbs of overmature Douglas-fir. The high incidence of *S. unispinosus* in fresh slash makes this species a potential danger, for it is capable of developing unusually high populations in a very short period of time. An illustration of this potential can be seen in a near epidemic outbreak of *S. unispinosus* which occurred over a 1,000 square mile area of Humboldt Co., California, in 1958. A combination of factors which commonly leads to epidemic conditions was in effect during 1957 and 1958. A prodigious accumulation of slash from logging operations and winter blow-down provided ample brood material, and a late fall gave an extended period for development of populations. Standing trees were then weakened due to an unusually hot and dry summer and became suitable hosts for the increased populations of *S. unispinosus*. However, just as natural conditions contributed to the population buildup, natural conditions counteracted the buildup, for the following years saw a sharp decrease in the population of *S. unispinosus* to its usual moderate level (Stevens, 1959). In addition to weather, Johnson (unpublished) found certain correlations between the low productivity of serpentine-based soils in Humboldt Co., California, with sporadic outbreaks of *S. unispinosus*.

The most destructive member of the genus is *Scolytus ventralis*, the fir engraver beetle, which attacks all true firs (*Abies* spp.) in its range. Population levels of this species tend to remain high from year to year and in California alone this species is responsible for the loss of 450 million board feet of timber each year (Stevens, 1956). With epidemic conditions, the losses are often much higher. For example, in 1954 *S. ventralis* killed some 37,000 trees on a 6,000 acre portion of the Cibola National Forest in New Mexico. Outbreaks of *S. ventralis* occur at irregular intervals and cause severe damage simultaneously in many different and widely-separated localities. Outbreaks of this nature have occurred in California, Oregon, and Washington at least once a decade since 1925 (Struble, 1957). Fading and reddish-brown tops, old spike tops, and secondary terminal leaders forming new tops

are common in true fir forests due to the characteristic manner in which *S. ventralis* often initiates attacks. Although many other species of bark beetles cannot develop broods without first killing the tree, *S. ventralis* is able to attack and establish broods when only a portion of the cambium tissue has been killed. In many cases, this patch killing does not directly result in the death of the tree; however, trees attacked in this manner are weakened and thus susceptable to attack by other agents, such as fungal rots and secondary insects. The high degree of rot and localized defects so common to fir is traceable to attack by *S. ventralis* and the subsequent healing-over of such areas by callus tissue. A considerable volume of otherwise valuable sawtimber is rendered unusable in this manner (Struble, 1957).

GENERAL LIFE HISTORY AND HABITS

All bark beetles including *Scolytus* undergo complete metamorphosis. The larva represents the feeding and growing stage, the pupa represents the resting or redevelopmental stage, and the adult represents the reproductive and locomotor stage.

The winter is spent primarily in the larval stage or, less frequently, in the adult stage. With favorable higher temperatures in the spring, newly matured adults emerge and reinfest new host material after a short flight period. Fresh slash as the result of recent logging or windthrown timber is preferred; however, standing trees are often attacked by most species of *Scolytus*. With endemic populations, the standing trees selected for attack ordinarily are either overmature, unthrifty, or weakened by disease, drought, or other factors. With epidemic conditions healthy trees are selected as well. Depending upon the species, attacks may be made on the main bole, top portion of the tree, or just the limbs.

The females initiate the attack by boring through the bark into the cambium region under the bark. She constructs a widened area in the sapwood to form a nuptial chamber and is soon joined by a single male. Mating takes place at frequent intervals in the nuptial chamber

during the egg laying period. The female constructs a single egg gallery or two separate egg galleries from the nuptial chamber along which she deposits eggs in single niches. The egg galleries of all coniferous *Scolytus* score both the sapwood and the phloem tissue, and it is this characteristic of bark beetles in general which can often result in the death of the host tree. The combined effect of many adult galleries, as well as the mines produced by the larvae, results in the complete circumscribing of the phloem tissue. A break in the continuity of the phloem tissue is fatal because this tissue conducts food materials throughout the tree. From the egg galleries, the developing larvae feed primarily on the phloem tissue but etch the sapwood lightly. When fully developed the larvae construct pupation chambers at the end of their larval mines, and in these chambers the pupae transform into adults, which bore from the tree and select a new host to repeat the life cycle (McMullin, L. H. and M. D. Atkins, 1957 and 1959).

GENUS *SCOLYTUS* GEOFFROY, 1762

The generic name *Scolytus* was originally designated by Geoffroy in 1762 in his description of *Scolytus scolytus*, a common European species occurring on Elms (*Ulmus* spp.), but in 1793 Herbst designated the name *Eccoptogaster*. Until early in the present century, all but a few entomologists had accepted the priority of the name *Scolytus* Geoffroy; however, certain workers protested the validity of the name, saying that Geoffroy's description of the type was inadequate and that his use of a binary as opposed to a binomial name was incorrect. As a result of this protest, Swaine (1917) described three species of the genus under the generic name *Eccoptogaster* (*S. piceae, S. tsugae, and S. monticolae*). The ruling of the Fifth Zoological Congress in 1901 establishing the laws of priority should have settled the issue, but differences of opinion in the interpretation of these laws kept the issue from final settlement (Blackman, 1934). It remained for the Commission of Zoological Nomenclature to make the final ruling in 1963, unquestionably establishing the priority and validity of the name *Scolytus*

Geoffroy as the true generic name (China, 1963).

The genus *Scolytus* is placed in the subfamily Scolytinae and is unique from all other genera of bark beetles in having sternites II, III, IV, and V of the abdomen characteristically arranged to form a distinct ventral concavity (figs. 4, 5). Sternite I is oriented nearly parallel to the ventral plane of the body or slightly upturned at its posterior margin. Sternite II is the largest of the sternites and is oriented nearly perpendicular to the ventral plane of the body. The anterior margin of sternite II can consist of a weakly elevated ridge or can be strongly elevated and lip-like. The ventral region of the concavity can thus be evenly rounded or bear a distinct caudal projection. Certain species have an intermediate condition in which the ventral region of the concavity bears a moderately and evenly elevated lip-like projection. Sternites III and IV are short in length and usually ascend at an oblique angle. Sternite V is commonly equal in length to sternites III and IV combined but may be shorter and ascends at an obique to nearly vertical angle. The posterior region of sternite V is variously elevated to form a lip-like projection which is commonly recurved somewhat over the ventral concavity. Some members of the genus are further characterized by having one or more of the abdominal sternites produced to form a spine, carina, tubercle, or denticle. The adult beetles are brownish-black to coal-black in color, relatively smooth in texture, and shiny in luster. The head commonly projects forward and is visible from above. Adults range in length from 2.2 to 4.9 mm and are approximately twice as long as wide.

In addition to the seventeen species considered here, there are six species in the genus *Scolytus* in North America which occur on hardwood trees and various fruit trees. Blackman's (1934) revision of the genus, including species attacking hardwoods, listed twenty-three North American species. Of the hardwood species, three are considered of economic importance: *S. rugulosus* Ratzeburg has been reported causing damage in orchards where sanitation has been neglected and the vigor of the trees has been allowed to deteriorate, *S. quadrispinosus* Say has killed large numbers of hickory trees in the East under favorable

climatic conditions, and *S. multistriatus* Marsham is a serious pest of elm in the East where it is a vector for the Dutch elm disease (Blackman, 1934).

As stated previously, the purpose of the material presented here is to provide the forester with a means of distinguishing the various coniferous species of *Scolytus*. To facilitate this end, the forester should keep in mind the following information. Since there is often considerable variation within any one species of *Scolytus*, more than one specimen should be examined for species determination. Ideally, to identify an unknown species, one should have series of both males and females, an accurate record of the host and collection locality, and several damage patterns correlated with their adults. Damage patterns are especially variable, and using just one adult gallery could be misleading if the gallery happened to be placed in the close proximity of a knot, causing distortion and an atypical gallery pattern. A point worth noting is that galleries of *Scolytus* collected late in the summer or fall commonly contain just one adult instead of the two adults more typical of early summer; the single adult is ordinarily a female.

DIFFERENTIATION OF MALES FROM FEMALES

The following key is designated for the keying of adult males only; thus, males must be distinguished from females. The most distinguishing character used to separate males of coniferous *Scolytus* is the relative flatness of the front of the head (figs. 7, 8) as compared to the more convex front of the females (figs. 9, 10). The front of the male may be somewhat convex in some species, but the female is always more strongly convex. The hair projecting from the front of the head is longer and more dense on the males as compared to the females. With the exception of *S. piceae*, the spines, carinae, tubercles, or denticles produced from the sternites of the ventral concavity are more pronounced on the males than on the females (figs. 4, 5). For example, a spine produced from sternite II of a male may be reduced to a tuber-

cle be lacking altogether on the female of the same species. When the anterior margin of sternite II is lip-like, the margin is more produced in males than females. The lip-like projection of the male may be represented by a weakly-produced margin on the female. With the exception of *S. wickhami*, *S. reflexus*, and *S. fiskei* which all have sternite V reduced in both sexes, sternite V of the male is somewhat shorter in length than that of sternites III and IV combined, while on the female sternite V is ordinarily slightly longer than sternite III and IV combined. In addition, the female of many species have the anterior margins of the punctures at the base of the elytra elevated, while this is not true in the case of males. Females are commonly slightly larger in size than males.

For the purpose of clarifying terminology used in the following key, a glossary of terms is included on page 34.

AN ANNOTATED AND ILLUSTRATED KEY TO ADULT MALES

1. Ventral or lateral margin of sternite II produced, forming a lip along the ventral portion of the concavity (figs. 33, 37, 57); adult gallery longitudinal, transverse, or oblique to the grain of the wood (figs. 87, 92, 95).....6, page 15

1'. Concavity rounded in ventral region, anterior margin of sternite II a weakly-elevated ridge (figs. 17, 25); adult gallery extending with the grain of the wood (figs. 80, 82).....2

2. Sternite V not reflexed, posterior region of sternite evenly produced (figs. 17, 25).....3

2'. Sternite V strongly reflexed (figs. 13, 14), with posterior margin of sternite distinctly produced at central apex, forming a ventrally directed lip over concavity .....*Scolytus reflexus* Blackman

SIZE - Medium sized, length 2.9 to 3.8 mm, average length 3.6 mm; 2.4 times longer than wide.

COMPARATIVE NOTES - *S. reflexus* most closely resembles *S. wickhami* but can be distinguished from *S. wickhami* and all other *Scolytus* by having sternite V strongly reflexed (figs. 13, 14). *S. reflexus* is distinguished from all other species with the concavity rounded in the ventral region by the absence of a spine on sternite II. The antennal club of *S. reflexus* (fig. 12) is distinctive in outline, shape of suture I, and arrangement of setae.

DISTRIBUTION - The distribution of this species (fig. 96) is poorly known. Specimens have been collected from the Santa Catalina and Chiricahua Mountains of southern Arizona and from the Mexican Plateau near Chiricahua, Mexico.

HOST - Known only from Douglas-fir, *Pseudotsuga menziesii*.

DAMAGE PATTERN - The adult gallery of *S. reflexus* (fig. 79) is bayonet-shaped, or occasionally in the shape of a tuning fork, with a central nuptial chamber. From the distinct nuptial chamber, one egg gallery extends directly with the grain of the wood, while the other egg gallery runs against the grain for a short distance before turning to extend with the grain. The nuptial chamber may also extend with the grain for a short distance. The adult gallery equally scores the sapwood and the phloem and ranges in length from 1.5 to 3.0 inches. Egg niches lightly score the sapwood and are closely spaced along the egg galleries. Larval mines form a fan-shaped pattern, and pupation chambers are often located in the sapwood. This species most commonly attacks the limbs of its host but is also found in fresh slash.

3. Sternite II produced at posterior margin forming a blunt spine (figs. 21, 25, 29), the base of which extends from the posterior margin to about the middle of the sternite; host variable.....4

3'. Sternite II produced in central region to form a long, conical, and acute spine with a sharply pointed apex (figs. 17, 18); principle host *Picea*.....*Scolytus piceae* (Swaine)

SIZE - Medium sized, length 2.4 to 3.3 mm, average length 2.8 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. piceae* can be distinguished from all other *Scolytus* by the position of the spine on sternite II (figs. 17, 18), the base of the spine having no connection with the posterior margin of sternite II as do all other one-spined species (figs. 21, 25, 29).

DISTRIBUTION - *S. piceae* has the most extensive distribution of the North American species of *Scolytus* (fig. 97). Its range extends from the northern New England States across Canada to Alaska and into the Rocky Mountains and Sierra Nevada Mountains wherever spruce is a significant component of the coniferous forest. In the United States this species has been recorded from Alaska, California, Colorado, Idaho, Maine, Massachusetts, Michigan, Montana, New York, North Dakota, Utah, Washington, Wisconsin, Wyoming; and in Canada from the provinces of British Columbia, Manitoba, and Quebec.

HOST - Most species of spruce, *Picea* spp., within the range of *S. piceae* including *P. breweriana, P. canadensis, P. engelmannii, P. glauca, P. pungens,* and *P. rubens*; incidental hosts, *Abies balsamae* and *Larix* spp.

DAMAGE PATTERN - The adult gallery of *S. piceae* (fig. 80) is often bayonet-shaped or occasionally in the shape of a tuning fork and with a central nuptial chamber. From the distinct nuptial chamber, one egg galley extends directly with the grain of the wood, while the other egg gallery runs against the grain for a short distance before turning to extend with the grain. The adult gallery equally scores the sapwood and the phloem or occasionally only lightly scores the sapwood. Adult galleries are 2.0 to 3.0 inches in length. Egg niches lightly score the sapwood and are widely spaced along the egg gallery. Larval mines are strongly divergent and form a fan-shaped pattern. Pupation chambers

deeply score the sapwood, commonly being circular in shape.

4. Spine on sternite II stout, slightly compressed basally, and distinctly rounded at its apex (figs. 21, 22); posterior margin of sternite V weakly elevated and strongly thickened along the lateral margin to the apex; front of head slightly concave with course and deep aciculations; principle host *Larix* spp.....*Scolytus laricis* Blackman

SIZE - Medium sized, length 2.6 to 3.5 mm, average length 3.1 mm; 2.4 times longer than wide.

COMPARATIVE NOTES - *S. laricis* most closely resembles *S. unispinosus* and *S. fiskei* but can be distinguished by the stout spine with a distinctly rounded apex (figs. 21, 22); the spine of *S. unispinosus* and *S. fiskei* (figs. 25, 29) is more strongly compressed. *S. laricis* has the posterior margin of sternite V (figs. 21, 22) weakly elevated and strongly thickened, while the posterior margin of *S. unispinosus* and *S. fiskei* (figs. 25, 29) is moderately and evenly elevated. The front of the head of *S. laricis* is slightly concave and coursely aciculate; whereas, the front of *S. unispinosus* and *S. fiskei* is finely aciculate and somewhat convex. The antennal club of *S. laricis* (fig. 20) differs from other *Scolytus* in outline, shape of suture I, and arrangement of setae. *S. unispinosus* and *S. fiskei* do not commonly attack *Larix* spp.

DISTRIBUTION - This species (fig. 98) ranges in the Pacific Coast Region from Oregon, through Washington to British Columbia, Canada, and inland to Idaho and Montana.

HOST - Larch, *Larix* spp., including *L. occidentalis* and *L. lyallii*.

DAMAGE PATTERN - The adult gallery of *S. laricis* (fig. 81) is nearly straight with the grain of the wood. The nuptial chamber is central and extends at right angles to the main gallery. Opposite the nuptial chamber is a distinct semicircular turning niche. From the nuptial chamber the two egg galleries extend in opposite directions with the grain. The adult gallery scores the sapwood more deeply than

the phloem and ranges in length from 2.5 to 4.5 inches. Egg niches distinctly etch the sapwood and are widely spaced along the galleries. Larval mines extend nearly parallel to one another or may be gradually divergent. Mines terminate in circular pupation chambers which deeply score the sapwood. This species prefers the suppressed lower limbs of its host and can be found in fresh slash.

4'. Spine on sternite II long, more strongly compressed, and less rounded at its apex (figs. 25, 29); sternite V with posterior margin moderately and evenly elevated; front of head slightly to strongly aciculate.....5

5. Spine on sternite II with base extending from posterior margin to approximately one half the length of sternite (fig. 25, 26); concavity dull in luster and with punctures fine to nearly obscure (fig. 25); sternite V with length slightly less than that of sternite III and IV combined .....*Scolytus unispinosus* LeConte

SIZE - Small sized, length 2.3 to 3.1 mm, average length 2.6 mm; 2.2 times longer than wide.

COMPARATIVE NOTES - *S. unispinosus* is an extremely variable species. It most closely resembles *S. fiskei* but can be distinguished by the position of the spine on sternite II (figs. 25, 26) which extends approximately half the length of the sternite of *S. unispinosus* and three-fourths the length of the sternite of *S. fiskei* (figs. 29, 30). *S. unispinosus* has the concavity dull in luster, and brownish-black in color, while the concavity of *S. fiskei* is dark black and shiny in luster. Sternite V of *S. unispinosus* (fig. 25) has the length somewhat less than that of sternites III and IV combined; whereas, sternite V of *S. fiskei* (fig. 29) is slightly larger than sternite IV. The antennal club of *S. unispinosus* (fig. 24) differs from that of *S. fiskei* (fig. 28) in outline, shape of suture I, and arrangement of setae. While the ranges of these two species overlap, *S. unispinosus* ranges primarily along the Pacific Coast (fig. 99), while *S. fiskei* (fig. 100) ranges

primarily in the Rocky Mountain Region.

DISTRIBUTION - *S. unispinosus* (fig. 99) is widely distributed throughout California, Oregon, Washington, and the Canadian province of British Columbia.

HOST - Primary host Douglas-fir, *Pseudotsuga menziesii*; incidental hosts true firs, *Abies* spp., and hemlocks, *Tsuga* spp.

DAMAGE PATTERN - The adult gallery of *S. unispinosus* (fig. 82) usually consists of a single egg gallery extending with the grain of the wood from a basal chamber. The nuptial chamber is very distinct, usually including a short extention at a 45 degree angle in the opposite direction from that of the main gallery. Occasionally this extension is continued as a second egg gallery to form a bayonet-shaped adult gallery. The adult gallery usually scores the phloem more deeply than the sapwood and ranges in length from 1.5 to 4.5 inches. Larval mines often extend nearly parallel for a short distance before diverging to form a fan-shaped pattern. Pupation chambers are usually in the phloem or may lightly score the sapwood. This species is commonly found attacking the limbs and tops of its host but is more often found in fresh slash.

5'. Spine on sternite II with base extending from posterior margin to approximately three-fourths the length of the sternite (figs. 29, 30); concavity shiny in luster, dark black in color, and finely but distinctly punctured; sternite V slightly longer than sternite IV (fig. 29) .....*Scolytus fiskei* Blackman

SIZE - Small sized, length 2.4 to 3.4 mm, average length 2.8 mm; 2.3 times longer than wide.

COMPARATIVE NOTES - *S. fiskei* most closely resembles *S. unispinosus*, but can be distinguished by the arrangement of the spine on sternite II (figs. 29, 30) which extends from the posterior margin to approximately three-fourths the length of the sternite of *S. fiskei* and one-half the

length of the sternite of *S. unispinosus* (figs. 25, 26). *S. fiskei* has the concavity dark black in color, shiny in luster, and finely but distinctly punctured, while the concavity of *S. unispinosus* is brownish-black in color, dull in luster, and finely to obscurely punctured. *S. fiskei* has the length of sternite V reduced (fig. 29), being slightly longer than sternite IV; whereas, sternite V of *S. unispinosus* (fig. 25) is somewhat shorter than sternites III and IV combined. The antennal club of *S. fiskei* (fig. 28) differs from that of *S. unispinosus* in outline, shape of suture I, and arrangement of setae. While the ranges of these two species overlap, *S. fiskei* (fig. 100) occurs primarily in the Rocky Mountain Region; whereas, *S. unispinosus* (fig. 99) occurs primarily along the Pacific Coast.

DISTRIBUTION - The distribution of *S. fiskei* (fig. 100) extends from British Columbia, Canada, into Washington and down the Rocky Mountains through Idaho, Montana, Wyoming, Colorado, Utah, Arizona, and New Mexico.

HOST - Douglas-fir, *Pseudotsuga menziesii*, and grand fir, *Abies grandis*.

DAMAGE PATTERN - The adult gallery of *S. fiskei* (fig. 83) is bayonet-shaped with a central nuptial chamber. From the distinct nuptial chamber, one egg gallery runs against the grain for a short distance before turning to extend with the grain of the wood, while the other egg gallery extends directly with the grain. Opposite the nuptial chamber is often a distinct semicircular turning niche. The adult gallery usually engraves the phloem more deeply than the sapwood and ranges in length from 1.5 to 3.o inches. Egg niches lightly etch the sapwood and are unevenly placed along the gallery. Larval mines usually turn abruptly to form a fan-shaped pattern, commonly terminating in pupation chambers which lightly score the sapwood. Attack is usually centered on the suppressed limbs and tops of the host as well as fresh slash.

6. One or more sternites of ventral concavity bearing a carina, tubercle, or denticle (figs. 57, 65, 73, 77); principle host true firs, *Abies* spp.....11, page 22

6'. Carinae, tubercles, or denticles lacking on sternites of ventral concavity (figs. 33, 37, 45, 49); principle hosts *Pseudotsuga*, *Tsuga*, or *Abies* spp.....7

7. Anterior margin of sternite II either distinctly thickened, or very strongly produced to form a lip at ventral apex (figs. 45, 49); principle hosts *Pseudotsuga* or *abies* spp.....10, page 20

7'. Anterior margin of sternite II moderately produced or nearly obscure at ventral apex and not forming a distinct lip (figs. 33, 37, 41).....8

8. Sternite V not reduced (figs. 37, 41), length nearly equal to that of sternites III and IV combined; elytra, at most, only slightly emarginate at either side of sutural dehiscence (figs. 35, 39); ranging along Pacific Coast and in northern Rocky Mountain Regions (figs. 102, 103).....9

8'. Sternite V reduced in size (figs. 33, 34) with length approximately equal to that of sternite IV; elytra deeply notched along posterior margin at either side of sutural dehiscence (fig. 31); ranging in Rocky Mountain States (fig. 101).....*Scolytus wickhami* Blackman

SIZE - Medium sized, length 2.7 to 3.7 mm, average length 3.2 mm; 2.3 times longer than wide.

COMPARATIVE NOTES - *S. wickhami* (figs. 33, 34) is distinguished from those *Scolytus* lacking a spine on sternite II (figs. 37, 41, 45, 49) and from all other *Scolytus* by having sternite V reduced in length, being approximately equal in length to that of sternite IV. *S. wickhami*

has the anterior margin of sternite II moderately and evenly elevated at its ventral apex (figs. 37, 38); whereas, the region of the ventral apex of *S. tsugae* (figs. 37, 38) and *S. monticolae* (figs. 41, 42) is usually somewhat rounded with the margin often obscure but produced into small cusps at either side of the ventral apex. *S. wickhami* has the elytra deeply notched along the posterior margin at either side of the sutural dehiscence (fig. 31), while *S. tsugae* (fig. 35) and *S. monticolae* (fig. 39) are at the most slightly emarginate in this region. The antennal club of *S. wickhami* is distinctive from other species of *Scolytus* in outline, shape of suture I, and arrangement of setae (fig. 32).

DISTRIBUTION - *S. wickhami* (fig. 101) occurs in the Rocky Mountain and Great Basin States of Arizona, Idaho, Nevada, New Mexico, Utah, and Wyoming.

HOST - Principle host Douglas-fir, *Pseudotsuga menziesii;* incidental hosts true firs, *Abies* spp., and pines, *Pinus* spp.

DAMAGE PATTERN - The adult gallery of *S. wickhami* (fig. 84) is bayonet-shaped or occasionally in the shape of a tuning fork. From a distinct, central nuptial chamber, one egg gallery extends directly with the grain of the wood, while the other egg gallery runs against the grain for a short distance before extending directly with the grain. The nuptial chamber may also extend with the grain for a short distance. Opposite the nuptial chamber there is commonly a distinct semicircular turning niche. The adult gallery often scores the phloem more deeply than the sapwood or may score both equally, ranging in length from 1.5 to 3.0 inches. Egg niches are distinct, in the sapwood, and often arranged in pairs along the gallery. Larval mines usually extend parallel for a short distance before diverging to form a fan-shaped pattern. Pupation chambers are usually located in the sapwood, being elongate or occasionally circular and deep in the sapwood. This species prefers the suppressed lower limbs of its host and is commonly found in fresh slash.

9. Sternite II dull in luster; elytra with striae deeply grooved to appear corrugated (fig. 35); front of head finely aciculate and somewhat convex between inner apices of eyes; adult gallery (fig. 85) extending transversely to obliquely against the grain of the wood .....*Scolytus tsugae* (Swaine)

SIZE - Medium sized, length 2.9 to 3.5 mm, average length 3.1 mm; 2.1 times longer than wide.

COMPARATIVE NOTES - *S. tsugae* most closely resembles *S. monticolae* but can be distinguished by the dull luster of sternite II, which is shiny on *S. monticolae*. The elytra of *S. tsugae* (fig. 35) is deeply grooved along the striae giving a corrugated effect; whereas, the elytra of *S. monticolae* (fig. 39), although occasionally somewhat corrugated, is usually only slightly grooved. *S. tsugae* has the front of the head finely aciculate and somewhat convex between the inner apices of the eyes, while *S. monticolae* is coursely aciculate and strongly flattened in this region. The antennal club of *S. tsugae* (fig. 36) differs from that of *S. monticolae* (fig. 40) in outline, shape of suture I, and arrangement of setae. *S. tsugae* can be distinguished from *S. wickhami* by having sternite V (fig. 37) nearly equal in length to that of sternites III and IV combined. The adult gallery of *S. tsugae* (fig. 85) differs from both *S. wickhami* (fig. 84) and *S. monticolae* (fig. 86) by extending transversely to obliquely against the grain; whereas, the adult galleries of the latter two species extend directly with the grain of the wood.

DISTRIBUTION - *S. tsugae* (fig. 102) ranges along the Pacific Coast from California, through Oregon and Washington, to British Columbia, Canada, and inland to Idaho.

HOST - Principle hosts western hemlock, *Tsuga heterophylla*, and mountain hemlock, *T. mertensiana*: incidental hosts Douglas-fir, *Pseudotsuga menziesii*, and true firs, *Abies* spp.

DAMAGE PATTERN - The adult gallery of *S. tsugae* (fig. 85) is quite variable depending upon locality. Series taken in Oregon display an adult gallery which extends transversely against the grain, while a series taken in northern California displays an adult gallery which is orientated obliquely against the grain. The predominent adult gallery is the transverse type. From a central nuptial chamber, the two egg galleries extend in opposite directions directly against the grain of the wood. The adult gallery scores the phloem somewhat more deeply than the sapwood and ranges in length from 1.5 to 4.0 inches. Egg niches faintly score the sapwood and are irregularly spaced along the gallery. Larval mines faintly etch the sapwood at first but more deeply toward the ends; they often extend over six inches if uncrowded, commonly terminating in elongate pupation chambers which may be in the sapwood or the phloem. This species may attack the main bole of its host as well as the larger limbs. The northern California series displays the following variations. From the central nuptial chamber, the two egg galleries are at right angles to each other and oblique to the grain of the wood. The nuptial chamber may be a somewhat circular expansion of the adult gallery or a short extension in the opposite direction from that of the egg galleries. The adult gallery equally scores the sapwood and phloem and extends nearly four inches in length. Egg niches etch the sapwood and are closely spaced. Larval mines radiate from the outer surface of the gallery, extending nearly parallel from the inner surface of the gallery. Found attacking slash 3.0 to 4.0 inches in diameter.

9'. Sternite II shiny in luster; elytra with striae usually slightly grooved or occasionally somewhat corrugated (fig. 39); front of head strongly flattened to somewhat concave between inner apices of eyes; adult gallery (fig. 86) extending with the grain of the wood ..... *Scolytus monticola* (Swaine)

SIZE - Medium sized, length 2.7 to 3.6 mm, average length 3.0 mm; 2.3 times longer than wide.

COMPARATIVE NOTES - *S. monticolae* most closely resembles *S. tsugae* and *S. wickhami* but can be distinguished from *S. tsugae* by the shinness of sternite II which is dull in luster on *S. tsugae*, and from *S. wickhami* by having sternite V nearly equal in length to that of sternites III and IV combined (fig. 41), which on *S. wickhami* fig. 33 is equal in length to sternite IV. *S. monticolae* has the front of the head strongly flattened to somewhat concave between the inner apices of the eyes and is coursely aciculate; whereas, *S. tsugae* has the front finely aciculate and somewhat convex in this region. The elytral striae of *S. monticolae* (fig. 39) are slightly grooved or occasionally somewhat corrugated, while the elytral striae of *S. tsugae* (fig. 35) are deeply grooved appearing corrugated. The antennal club of *S. monticolae* (fig. 40) differs from that of *S. tsugae* (fig. 36) in outline, shape of suture I, and arrangement of setae. The principle host of *S. monticolae* is *Pseudotsugae menziesii*, while the hosts for *S. tsugae* are *Tsuga* spp.

DISTRIBUTION - The distribution of *S. monticolae* (fig. 103) extends along the Pacific Coast and inland to the northern Rocky Mountains; including the states of California, Colorado, Idaho, Montana, Oregon, Utah, Washington, and Wyoming, and the Canadian province of British Columbia.

HOST - Principle host Douglas-fir, *Pseudotsuga menziesii;* incidental hosts western white pine, *Pinus monticola*, hemlocks, *Tsuga* spp., and larch, *Larix* spp.

DAMAGE PATTERN - The adult gallery of *S. monticolae* (fig. 86) is bayonet-shaped and with a central nuptial chamber. From the nuptial chamber, one egg gallery extends directly with the grain of the wood, while the other egg gallery usually runs for a short distance against the grain before extending directly with the grain. The nuptial chamber is distinct and usually extends obliquely from the main gallery. The adult gallery scores the sapwood more deeply than the phloem and

ranges in length from 2.0 to 3.5 inches. Egg niches deeply score the sapwood and commonly occur in pairs along the gallery. Larval mines form a fan-shaped pattern, commonly terminating in pupation chambers which lightly score the sapwood. This species prefers the larger limbs of its host.

10. Anterior margin of sternite II distinctly thickened (fig. 45); surface of sternite II sharply depressed directly dorsal to anterior margin and faintly punctured; ranging in Pacific Coast States (fig. 104) .....*Scolytus oregoni* Blackman

SIZE - Medium sized, length 2.7 to 3.5 mm, average length 3.4 mm; 2.2 times longer than wide.

COMPARATIVE NOTES - *S. oregoni* is distinguished from other *Scolytus* by the characters of the ventral concavity. The anterior margin of sternite II (figs. 45, 46) is strongly thickened at its ventral apex, with the lateral portion of the margin distinctly flattened. Punctures on the surface of sternite II (fig. 45) are fine to nearly obscure. *S. oregoni* has the front of the head flattened and coursely aciculate. The antennal club (fig. 44) differs from other *Scolytus* in outline, shape of suture I, and arrangement of setae. The distribution of this species is limited to the Pacific Coast States (fig. 104).

DISTRIBUTION - *S. oregoni* (fig. 104) occurs in California, Oregon, and Washington. The distribution of this species is not well known.

HOST - Douglas-fir, *Pseudotsuga menziesii*, and bigcone Douglas-fir, *P. macrocarpa*.

DAMAGE PATTERN - The adult gallery of *S. oregoni* (fig. 87) is commonly straight with the grain of the wood or somewhat bayonet-shaped and with a central nuptial chamber. From the nuptial chamber, the two egg galleries extend in opposite directions directly with the grain. The nuptial chamber is usually a short right angle extension against the grain. The adult gallery scores the sapwood more deeply than the

phloem and ranges in length from 2.5 to 7.0 inches. Egg niches score the sapwood deeply and are often arranged in pairs along the gallery. Larval mines rapidly diverge to form a fan-shaped pattern, terminating in pupation chambers which score the sapwood. This species prefers the larger limbs and tops of its host and is common in fresh slash.

10'. Anterior margin of sternite II (figs. 49, 50) not strongly thickened but very distinctly produced at ventral apex to form a lip-like projection; surface of sternite II deeply and densely punctured; ranging in Rocky Mountain and Great Basin Regions (fig. 105).
.....*Scolytus robustus* Blackman

SIZE - Medium to large sized, length 2.5 to 4.1 mm, average length 3.3 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. robustus* most closely resembles *S. praeceps*. *S. robustus* has the lip-like anterior margin of sternite II (figs. 49, 50) somewhat truncate and produced at a slight ventral-oblique angle from the ventral plane of the body; whereas, the lip-like margin of *S. praeceps* (figs. 73, 74) is evenly rounded and produced parallel to the ventral plane of the body. The posterior margin of sternite II lacks a carina on *S. robustus*, while this region of *S. praeceps* is slightly elevated medially to form a carina. *S. robustus* has the front of the head strongly flattened and coursely aciculate, while the front of *S. praeceps* is evenly convex and faintly aciculate. The known ranges of these two species serve to distinguish them. *S. robustus* (fig. 105) ranges in the Rocky Mountain and Great Basin Regions, while *S. praeceps* (fig. 110) ranges in the Pacific Coast Region. *S. robustus* resembles *S. obelus* in its range, but *S. obelus* is distinguished by the presence of a denticle (figs. 78, 79) borne at the posterior margin of sternite II. The antennal club of *S. robustus* (fig. 48) is distinctive in outline, shape of suture I, and arrangement of setae.

DISTRIBUTION - *S. robustus* (fig. 105) ranges in the Rocky Mountain

and Great Basin States of Arizona, Colorado, Nevada, New Mexico, Texas, and Utah.

HOST - Principle host white fir, *Abies concolor*; incidental hosts subalpine fir, *A. lasiocarpa* and grand fir, *A grandis*.

DAMAGE PATTERN - The adult gallery of *S. robustus* (fig. 88) is variable in shape. Typically the adult gallery is an S-shaped pattern oriented with the grain of the wood. From the central nuptial chamber, one egg gallery extends obliquely against the grain for a short distance before recurving at its apex, while the other egg gallery extends in the opposite direction obliquely against the grain for a short distance before recurving at its apex. Occasionally both egg galleries extend with the grain in opposite directions and without recurving at their apices, or they may extend nearly transverse against the grain. The fact that the adult galleries of this species are often located around limb bases contributes to their irregularities in shape. The adult gallery usually scores the sapwood more deeply than the phloem and ranges in length from 1.0 to 2.5 inches. Egg niches are distinct, in the sapwood, and closely spaced along the gallery. Larval mines diverge rapidly to extend with the grain, terminating in elongate pupation chambers which score the sapwood. This species prefers the limbs and tops of its host and is common in fresh slash.

11. Posterior margin of sternite IV lacking an acute denticle (figs. 57, 65, 73); ranging extensively on various hosts.....12

11'. Posterior margin of sternite IV produced medially to form an acute denticle (figs. 53, 54); endemic to Santa Lucia Mountain Range, central California.
.....*Scolytus dentatus* Bright

SIZE - Large sized, length 3.6 to 4.5 mm, average length 4.0 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. dentatus* is distinguished from other *Scolytus* by the presence of a median denticle on the posterior margin of sternite IV (figs. 53, 54). The posterior margin of sternite II and III may also bear a median carina or acute tubercle. The large size, limited range, and distinctive host of this species also serve to distinguish it from other species of *Scolytus*.

DISTRIBUTION - This species is known only from the Santa Lucia Mountain Range, Monterey County, California.

HOST - Bristlecone fir, *Abies bracteata*.

DAMAGE PATTERN - The predominent shape of the adult gallery of *S. dentatus* (fig. 89) is that of an expanded-E oriented with the grain of the wood. From a distinct central nuptial chamber, the two egg galleries extend in opposite directions with the grain, each gallery terminating in a pronounced hook. The nuptial chamber is a short extension in the same, or in an opposite, direction from that of the terminal hooks. The adult gallery deeply scores the sapwood and ranges in length from 1.0 to 5.0 inches. Egg niches score the sapwood and are closely spaced. Larval mines form a fan-shaped pattern, terminating in pupation chambers which lightly score the sapwood. This species prefers the larger limbs and upper bole of its host as well as fresh slash.

12. Sternite II bearing a prominent carina which extends from the posterior margin toward the center of sternite (fig. 57, 61); carina most strongly elevated at its ventral apex.....13

12'. Sternite II bearing a less prominent, somewhat obscure, median carina, tubercle, or denticle (figs. 65, 69, 73 77); projection from sternite II most stronly elevated toward the posterior margin of sternite .....14, page

13. Sternite II with punctures deeply impressed and closely spaced (fig. 57); front of head flattened to a point just behind inner apices of eyes; ranging in Pacific Coast States and inland to Idaho (fig. 106)
.....*Scolytus abietis* Blackman

SIZE - Small sized, length 2.2 to 2.8 mm, average length 2.4 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. abietis* most closely resembles *S. opacus* but can be distinguished by the deeply impressed and closely spaced punctures on sternite II (fig. 57), which are widely spaced and finely impressed or nearly obscure on *S. opacus* (fig. 61). The carina of *S. abietis* (figs. 57, 58) is not distinctly narrower toward posterior margin of sternite II than at its apex and rarely extends more than half the length of the sternite; whereas,the carina of *S. opacus* (figs. 61, 62) commonly extends three-fourths the length of the sternite and is usually constricted toward the posterior margin. *S. abietis* has the surface of sternite II dark black and shiny, while this surface on *S. opacus* is brownish-black and dull or opaque in luster. *S. abietis* has the front of the head flattened to a point just behind the inner apices of the eyes, while the front of *S. opacus* is flattened to a point well behind the inner apices of the eyes. The antennal club of *S. abietis* (fig. 56) differs from that of *S. opacus* (fig. 60) in outline, shape of suture I, and arrangement of setae. The ranges of these two species (figs. 106, 107) overlap in Idaho but are otherwise distinctly separate. The principle hosts of these two species are different and *S. abietis* is also a smaller species than *S. opacus* .

DISTRIBUTION - *S. abietis* (fig. 106) ranges in the Pacific Coast States from northern California, through Oregon to Washington, and inland to Idaho.

HOST - Principle hosts grand fir, *Abies grandis*, and white fir, *A. concolor*; incidental hosts other true firs, *Abies* spp., and hemlocks, *Tsuga* spp.

DAMAGE PATTERN - The adult gallery of *S. abietis* (fig. 90) commonly has one egg gallery extending directly against the grain from a central nuptial chamber, while the other egg gallery extends at a 45 degree angle to the grain of the wood. Occasionally both egg galleries extend directly against the grain or in opposite directions obliquely against the grain. Often the egg gallery which extends directly against the grain gradually turns to run at a slight, oblique angle for about half its length. The adult gallery usually scores the sapwood and phloem equally and ranges in length from 0.7 to 2.0 inches. Egg niches indistinctly score the sapwood and are closely spaced. Larval mines extend nearly parallel to one another from the adult gallery if not crowded and terminate in elliptical pupation chambers which score the sapwood. *S. abietis* prefers smaller limbs and tops of its host and is common in fresh slash.

13'. Sternite II with punctures finely impressed to nearly obscure (fig. 61); front of head flattened to a point well behind inner apices of eyes; ranging in Rocky Mountain and Great Basin Regions and into Idaho (fig. 107).....*Scolytus opacus* Blackman

SIZE - Small sized, length 2.5 to 3.4 mm, average length 2.9 mm; 2.1 times longer than wide.

COMPARATIVE NOTES - *S. opacus* most closely resembles *S. abietis* but can be distinguished by having the punctures on sternite II (fig. 61) fine to nearly obscure; whereas, *S. abietis* (fig. 57) has the punctures deeply impressed and closely spaced. The carina of *S. opacus* (figs. 61, 62) is usually constricted toward the posterior margin of sternite II and often extends three-fourths the length of the sternite, while the carina of *S. abietis* (figs. 57, 58) is not distinctly narrower toward the posterior margin than at its apex and rarely extends more than half the length of the sternite. *S. opacus* has the surface of sternite II dull or opaque in luster and brownish-black in color,

while the surface of *S. abietis* is dark black and shiny. *S. opacus* has the front of the head flattened to a point well behind the inner apices of the eyes; whereas the front of *S. abietis* is flattened to a point just behind the inner apices of the eyes. The antennal club of *S. opacus* (fig. 60) differs from that of *S. abietis* (fig. 56) in outline, shape of suture I, and arrangement of setae. Although overlapping somewhat in Idaho, the ranges of these two species (figs. 106, 107) are distinct. The principle hosts of these two species are also different. The average length of *S. opacus* is somewhat greater than that of *S. abietis*.

DISTRIBUTION - The range of *S. opacus* (fig. 107) includes the Rocky Mountain and Great Basin States of Colorado, Idaho, Montana, Utah, and Wyoming.

HOST - Principle host subalpine fir, *Abies lasiocarpa*; incidental hosts Douglas-fir, *Pseudotsuga menziesii*, other true firs, *Abies* spp., and spruces, *Picea* spp.

DAMAGE PATTERN - The adult gallery of *S. opacus* (fig. 91) commonly has one egg gallery extending directly against the grain of the wood, while the other egg gallery extends at a 45 degree angle to the grain. Occasionally both egg galleries extend directly against the grain, in opposite directions obliquely against the grain, or in the same direction at 45 degree angles to the grain. The placement of the adult gallery on small limbs and in close proximity to twig bases contributes to irregularities in shape. The adult gallery usually scores the sapwood more deeply than the phloem and ranges in length from 1.0 to 2.5 inches. Egg niches score the sapwood and are closely spaced. Larval mines extend nearly parallel to one another, or their pattern becomes quite confused when crowded. Pupation chambers are commonly deep in the sapwood. This species prefers the tops and limbs of its host and is also found in fresh slash.

14. Anterior margin of sternite II strongly produced and lip-like at ventral apex (figs. 69, 73, 77); posterior margin of sternite II produced medially to form a slightly elevated carina or sharply pointed denticle (figs. 69, 73, 77).....15

14'. Anterior margin of sternite II moderately and evenly elevated along entire surface (figs. 65, 66); posterior margin of sternite II produced medially to form an acute tubercle with a pointed apex.....*Scolytus ventralis* LeConte

SIZE - Large sized, length 3.3 to 4.3 mm, average length 3.9 mm; 2.2 times longer than wide.

COMPARATIVE NOTES - *S. ventralis* is a variable species due to its extensive distribution (fig. 108) but can be distinguished by its large size, characters of the ventral concavity (figs. 65, 66), and characteristic damage pattern (fig. 92). *S. ventralis* resembles *S. subscaber*, *S. robustus*, and *S. praeceps* but can be distinguished by having the anterior margin of sternite II moderately and evenly produced (fig. 65, 66); whereas, these three species (figs. 49, 69, 73) have the anterior margin strongly lip-like at the ventral apex. *S. ventralis* has the posterior margin of sternite II (figs. 65, 66) produced to form an acute tubercle with a pointed apex, while *S. subscaber* and *S. praeceps* (figs. 69, 73) both bear a carina with a blunt apex at the posterior margin, and *S. robustus* (fig. 49) lacks a spine. The punctation on sternite II of *S. ventralis* is variable, being moderately fine on west coast specimens and distinctly impressed on Rocky Mountain specimens. *S. ventralis* has the front of the head evenly convex (figs. 7, 8), while *S. subscaber* and *S. robustus* have the front distinctly flattened to somewhat concave. The antennal club of *S. ventralis* (fig. 64) is also distinctive.

DISTRIBUTION - *S. ventralis* (fig. 108) ranges extensively west of the Rocky Mountains and northward into Canada; including the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico,

Oregon, Utah, Washington, and Wyoming, and the Canadian province of British Columbia.

HOST - Principle hosts white fir, *Abies concolor*; red fir, *A. magnifica*; and grand fir, *A. grandis*. Incidental hosts Douglas-fir, *Pseudotsuga menziesii;* other true firs, *Abies* spp.; hemlocks, *Tsuga* spp.; and spruces, *Picea* spp.

DAMAGE PATTERN - The adult gallery of *S. ventralis* (fig. 92) is bilateral against the grain of the wood with a distinct central nuptial chamber. The two egg galleries usually extend in opposite directions directly against the grain. The nuptial chamber deeply grooves the sapwood and is usually a short right angled extension from the main gallery. Occasionally the nuptial chamber extends at an oblique angle, and when this condition exists, one of the egg galleries commonly runs at an oblique angle against the grain for a short distance before extending directly against the grain. Rarely, one egg gallery will loop over the nuptial chamber to run parallel with the other egg gallery. the adult gallery usually scores the sapwood more deeply than the phloem and ranges in length from 3.0 to 12.0 inches when fully developed. Egg niches are V-shaped in the sapwood and are unevenly arranged along the gallery, being closely spaced in one portion, widely spaced in another, and distinctly arranged in pairs in other portions. Larval mines extend nearly parallel to one another, often running for long distances if not crowded. The pattern of larval mines from both sides of the adult gallery often forms the shape of a diamond. Pupation chambers may score the sapwood but are commonly located in the phloem or outer bark. *S. ventralis* most commonly attacks the main bole of young pole-sized timber and the tops of older mature timber. This species is also found attacking fresh slash.

15. Sternite II distinctly punctured and somewhat shiny in luster (fig. 73, 77); front of head evenly convex and sparsely hairy; less than 3.2 mm long.....16

15'. Surface of sternite II finely or obscurely punctured and opaque in luster (fig. 69); front of head distinctly flattened and densely hairy; more than 3.3 mm long .....*Scolytus subscaber* LeConte

SIZE - Large sized, length 3.2 to 4.9 mm, average length 4.0 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. subscaber* most closely resembles *S. praeceps* and *S. ventralis* but can be distinguished from *S. praeceps* by having the surface of sternite II very finely to obscurely punctured and from *S. ventralis* by having the anterior margin of sternite II (figs. 69, 70) distinctly produced and lip-like; whereas, *S. ventralis* has the anterior margin of sternite II moderately and evenly produced (fig. 65), and *S. praeceps* has the surface of sternite II (fig. 73) distinctly punctured. *S. subscaber* bears a slightly elevated carina at the posterior margin of sternite II, while *S. ventralis* bears an acute tubercle with a pointed apex in this region. *S. subscaber* has the front of the head strongly flattened and coursely aciculate, while *S. ventralis* and *S. praeceps* have the front evenly convex and finely to moderately aciculate. The antennal club of *S. subscaber* differs from other species of *Scolytus* in outline, shape of suture I, and arrangement of setae (fig. 68). The adult gallery of *S. subscaber* (fig. 109) is distinct from all other *Scolytus*. The large size of *S. subscaber* can also be used to distinguish this species.

DISTRIBUTION - *S. subscaber* (fig. 109) ranges along the Pacific Coast from California through Oregon and Washington to British Columbia, Canada, and inland to Idaho.

HOST - Principle hosts white fir, *Abies concolor*, and red fir, *A. magnifica*; incidental host grand fir, *A. grandis*.

DAMAGE PATTERN - The adult gallery of *S. subscaber* (fig. 93) is distinct from all other *Scolytus* in that it has the shape of a rounded capital-E. The nuptial chamber is central, and the two egg galleries recurve around it. The adult gallery scores the sapwood more deeply than the phloem and is less than an inch across the diameter. Egg niches lightly score the sapwood and are located around the outer margin of the gallery. Larval mines extend in all directions from the adult gallery, usually not scoring the sapwood until late in their development. Pupation chambers are usually located in the phloem or outer bark. This species prefers the suppressed lower limbs of overmature host trees and is not commonly found attacking fresh slash.

16. Posterior margin of sternite II produced medially to form a weakly elevated carina (figs. 73, 74); front of head evenly convex but with a slight depression directly behind epistomal process; ranging in Pacific Coast States (fig. 110).....*Scolytus praeceps* LeConte

SIZE - Small sized, length 2.2 to 3.0 mm, average length 2.6 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. praeceps* most closely resembles *S. obelus* but can be distinguished by the presence of a carina produced at the posterior margin of sternite II (figs. 73, 74), while this region on *S. obelus* (figs. 77, 78) bears a distinct denticle with a sharply pointed apex. *S. praeceps* has the front of the head evenly convex between the inner apices of the eyes and may bear a slight depression directly behind the epistomal process; whereas, *S. obelus*, although evenly convex between the inner apices of the eyes, commonly bears a distinct depression or concavity directly behind the epistomal process. The antennal club of *S. praeceps* (fig. 72) differs slightly from *S. obelus* (fig. 76) in outline, shape of suture I, and arrangement of setae. *S. praeceps* (fig. 110) ranges in the Pacific Coast Region and is a common associate of *S. ventralis*; *S. obelus* (fig. 111) ranges in

the Rocky Mountain and Great Basin Region and is a common associate of both *S. ventralis* and *S. robustus*.

DISTRIBUTION - *S. praeceps* (fig. 110) occurs in the Pacific Coast States of California, Oregon, and Washington.

HOST - Principle hosts white fir, *Abies concolor*, and red fir, *A. magnifica*; incidental hosts include other true firs, *Abies* spp., and hemlocks, *Tsuga* spp.

DAMAGE PATTERN - The adult gallery of *S. praeceps* (fig. 94) commonly has one egg gallery extending directly against the grain of the wood, while the other egg gallery extends at a 45 degree angle to the grain. The nuptial chamber extends with the grain and is central. Occasionally both egg galleries extend in opposite directions obliquely against the grain, directly against the grain, or at 45 degree angles to the grain in the same direction. The habit of this species to initiate galleries in close proximity to twig bases often contributes to the variable arrangement of adult galleries. The adult gallery usually scores the sapwood more deeply than the phloem and ranges in length from 1.0 to 2.5 inches. Egg niches distinctly etch the sapwood and are quite closely spaced along the gallery. Larval mines strongly diverge from the main gallery to form a fan-shaped pattern. Pupation chambers are elongate and deeply score the sapwood. This species prefers the smaller limbs and topmost portions of its host but is also commonly found in fresh slash.

16'. Posterior margin of sternite II produced medially to form a distinctly elevated denticle (figs. 77, 78); front of head evenly convex, but with a distinct depression or concavity directly behind epistomal process; ranging in Rocky Mountain and Great Basin States (fig. 111) .....*Scolytus obelus* Wood

SIZE - Small sized, length 2.1 to 3.0 mm, average length 2.6 mm; 2.0 times longer than wide.

COMPARATIVE NOTES - *S. obelus* most closely resembles *S. praeceps* but can be distinguished by the presence of a distinctly elevated denticle at the posterior margin of sternite II (figs. 77, 78); whereas, *S. praeceps* (figs. 73, 74) bears a weakly elevated carina in this region. *S. obelus* has the front of the head evenly convex but is distinctly depressed or concave directly behind the epistomal process, while *S. praeceps* also has the front evenly convex but is only slightly depressed directly behind the epistomal process. *S. obelus* (fig. 111) ranges in the Rocky Mountain and Great Basin States and is a common associate of both *S. ventralis* and *S. robustus*, while *S. praeceps* (fig. 110) ranges along the Pacific Coast and is a common associate of *S. ventralis*.

DISTRIBUTION - *S. obelus* (fig. 111) ranges in the Rocky Mountain and Great Basin States, including Arizona, Colorado, Nevada, New Mexico, Texas, and Utah.

HOST - Principle hosts white fir, *Abies concolor*, and corkbark fir, *A. lasiocarpa* variety *arizonica*; incidental host subalpine fir, *A. lasiocarpa*.

DAMAGE PATTERN - The adult gallery of *S. obelus* (fig. 95) commonly has one egg gallery extending from the central nuptial chamber directly against the grain of the wood, while the other egg gallery extends at a 45 degree angle to the grain. Occasionally both egg galleries extend directly against the grain, or both extend in opposite directions obliquely against the grain. The habit of this species to initiate its galleries in close proximity to twig bases often contributes to the variable arrangement of adult galleries. The adult gallery usually scores the sapwood more deeply than the phloem, ranging in length from 0.7 to 2.5 inches. Egg niches score the sapwood and are closely spaced along the gallery. Larval mines are gradually divergent and terminate in pupation chambers which score the sapwood deeply. This species prefers the limbs and tops of its host and is commonly found in fresh slash.

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STRUCTURAL CHARACTERISTICS - A GLOSSARY OF TERMS

Head

ACICULATIONS - (fig. 2) Referring to the nearly parallel grooves or scratches on the surface of the front which may be course, as if made with a knife, or fine, as if made with a needle.

ANTENNAL CLUB - (fig. 3) That portion of the antenna which is flattened and elliptical in outline and which bears one prominent suture and two indistinct sutures.

EPISTOMAL PROCESS - (fig. 2) The lower portion of the face just dorsal to the mandibles, being variously elevated and emarginate at its ventral margin.

FRONT - (fig. 2) That region of the face from the epistomal margin to a point somewhat dorsal to the inner apices of the eyes; referring to that region which is variously flattened, concave, or convex; this region is also variously aciculate.

INNER APICES OF EYES - (fig. 2) The innermost mesal margins of the eyes as viewed frontally; referring to that level of the front between the mesal apices of the eyes.

Elytra

STRIAE - (fig. 1) The longitudinal lines or grooves extending along the dorsal surface of the elytra which are often deeply impressed to give the elytra a corrugated appearance.

SURTURAL DEHISCENCE - (fig. 1) The central notch at the posterior margin of the elytra.

Ventral Concavity

CARINA - (figs. 57, 58) A ridge-like or keel-like projection of the exoskeleton with a blunt apex; borne on sternite II.

CUSP - (figs. 37, 38) A slight projection or elevation along a margin; referring to the projections formed along the anterior margin of sternite II at either side of the ventral apex of the margin in various species.

DENTICLE - (figs. 53,54) A slightly recurved tooth-like projection of the exoskeleton with a sharply pointed apex; borne on sternite II or IV of various species.

OPAQUE - Dull in luster; referring to a surface which reflects very little light.

PRODUCED - Refers to a surface which is drawn-out, lengthened, or elevated in some manner; the anterior margin of sternite II is often produced to form a lip-like projection.

SHINY - Glossy or bright in luster as if varnished; referring to a surface which reflects light well.

SPINE - (figs. 17, 18, 25, 26) An elongate projection of the exoskeleton which is considerably longer than its basal width; borne centrally or from the posterior margin of sternite II.

STERNITE (figs. 4, 5) A ventral plate or sclerite of the abdomen; in *Scolytus* there are five externally visible sternites.

TUBERCLE - (figs. 4, 5) A slightly produced projection of the exoskeleton usually no longer than its basal width and with a relatively blunt to somewhat pointed apex; borne at the posterior margin of sternite II.

VENTRAL APEX - (figs. 4, 5) Referring to the ventral-most portion of the anterior margin of sternite II which is variously elevated or depressed.

Damage Pattern

ADULT GALLERY - (fig. 6) The composite tunnel produced by the adult beetles, including one or two egg galleries, the nuptial chamber, and the egg niches produced along the egg galleries.

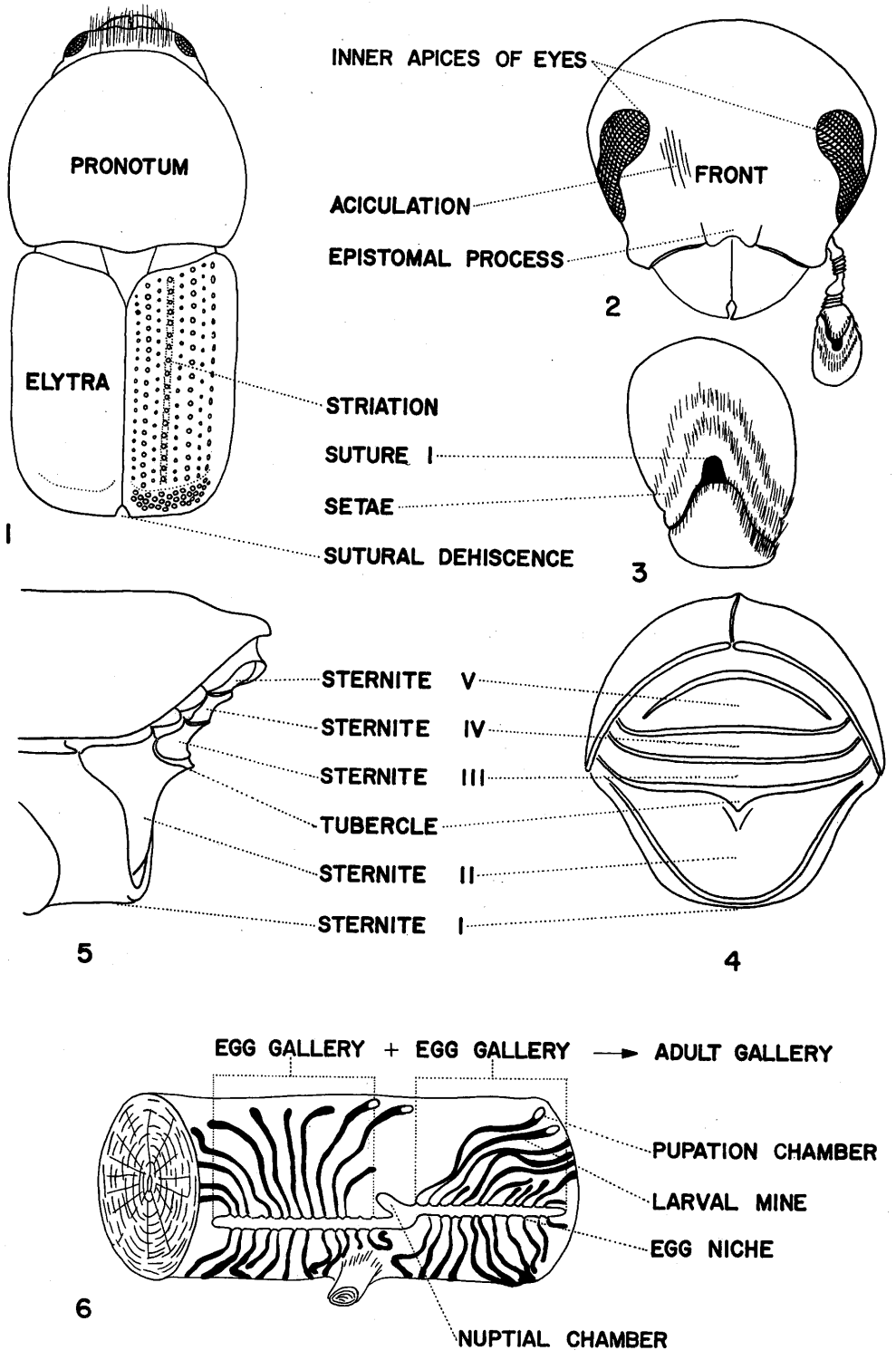
EGG GALLERY - (fig. 6) A single extension of the adult gallery from the nuptial chamber along which eggs are deposited in niches; certain species of *Scolytus* construct just one egg gallery, while others construct two egg galleries or occasionally more than two.

EGG NICHE - (fig. 6) The notches or grooves along the sides of the egg galleries in which the female singly deposits her eggs.

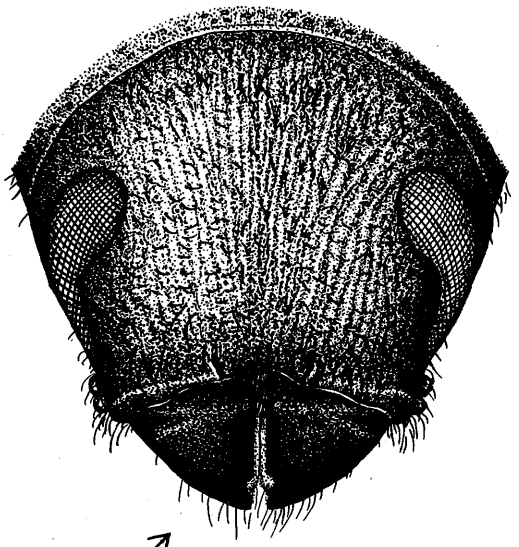
LARVAL MINE - (fig. 6) The excavation tunnel produced by the larva as it feeds in the sapwood or phloem tissue; the larval mine is usually packed with frass.

NUPTIAL CHAMBER - (fig. 6) An enlarged area or short extension at a right or oblique angle from the adult gallery which is associated with the entrance hole; the nuptial chamber scores the sapwood and may be basal or central in position along the adult gallery.

PUPATION CHAMBER - (fig. 6) The elongate or circular excavation at the end of a successful larval mine in which pupation occurs; pupation chambers may be located in the sapwood, phloem, or outer bark.


PRONOTUM
ELYTRA
STRIATION
SUTURE I
SETAE
SUTURAL DEHISCENCE
1
INNER APICES OF EYES
FRONT
ACICULATION
EPISTOMAL PROCESS
2
3
STERNITE V
STERNITE IV
STERNITE III
TUBERCLE
STERNITE II
STERNITE I
5
4
EGG GALLERY + EGG GALLERY → ADULT GALLERY
PUPATION CHAMBER
LARVAL MINE
EGG NICHE
NUPTIAL CHAMBER
6

S. ventralis



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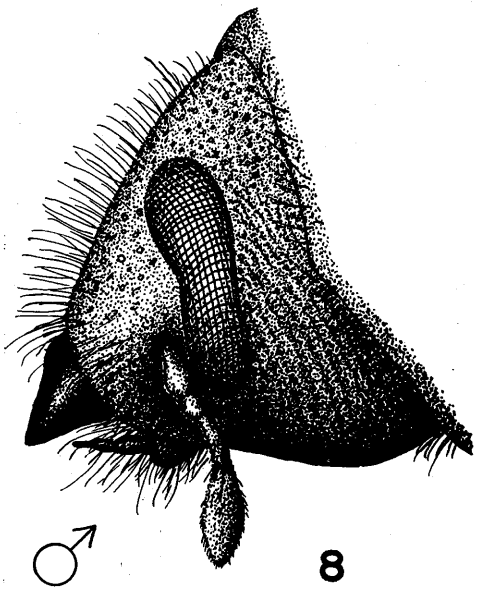

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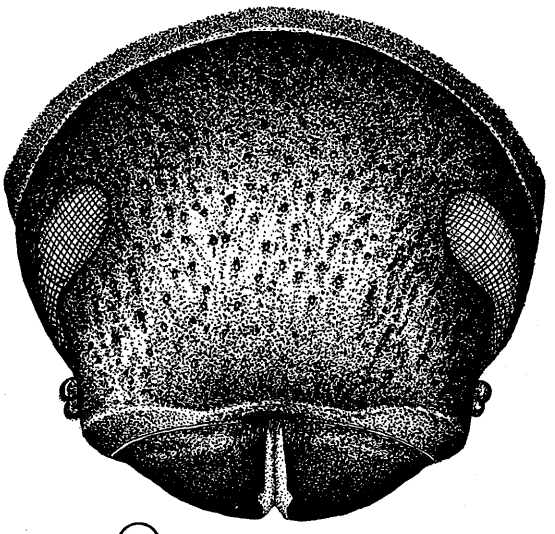

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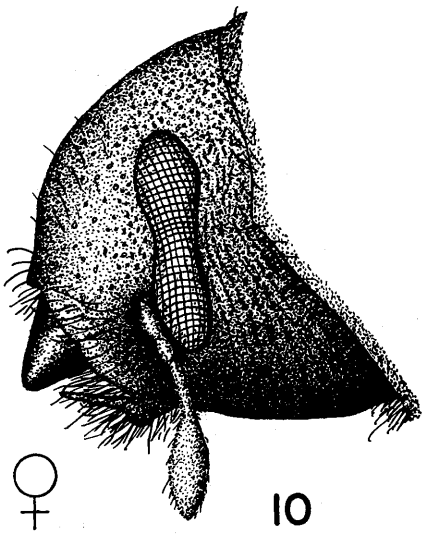

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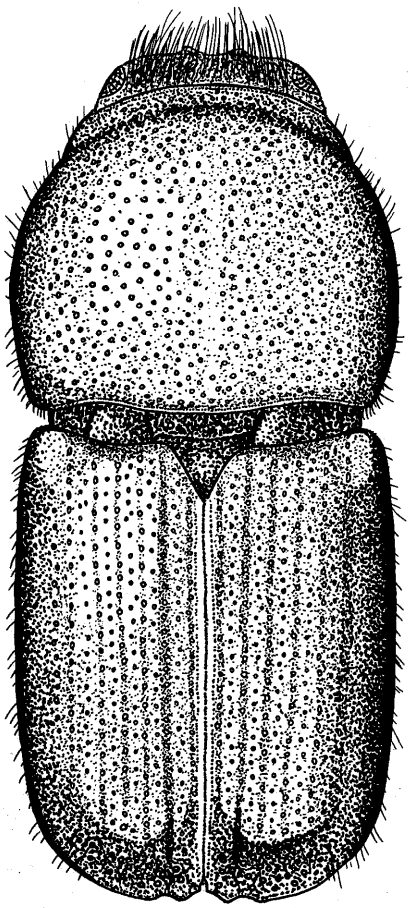
S. reflexus



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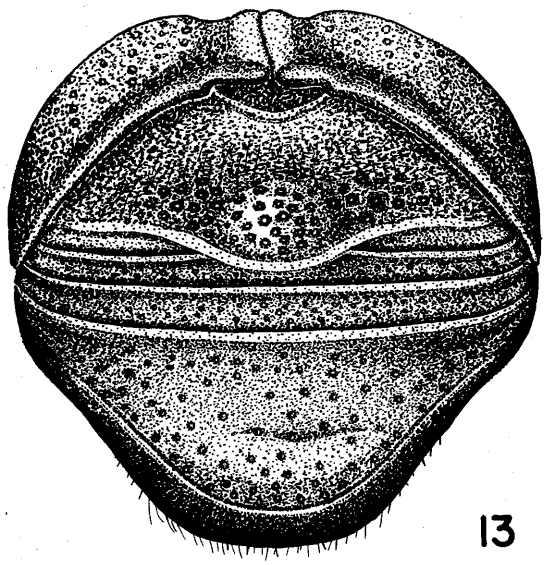

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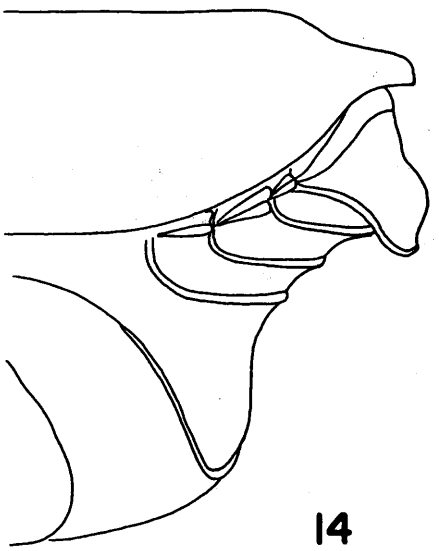

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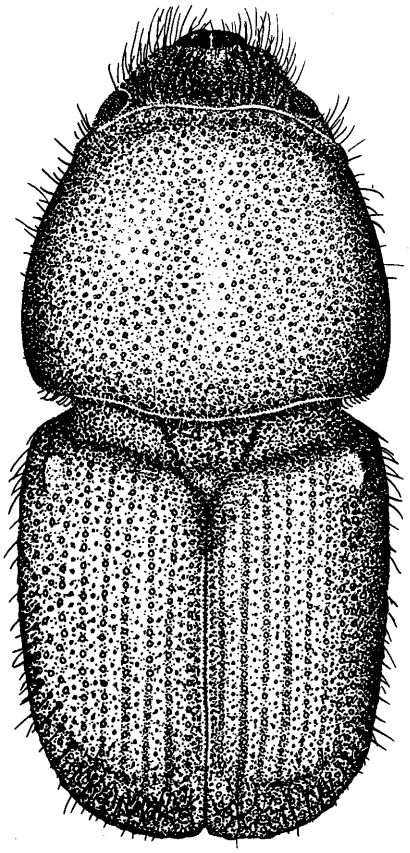
S. piceae



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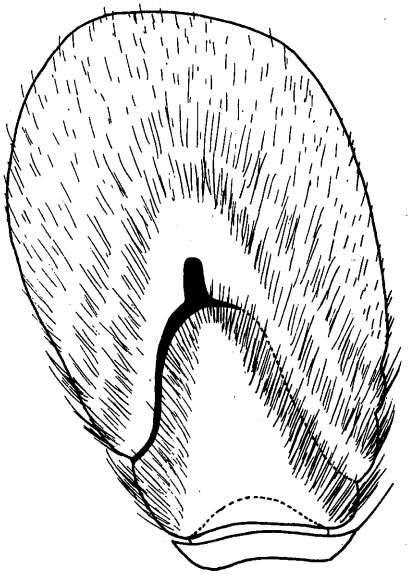

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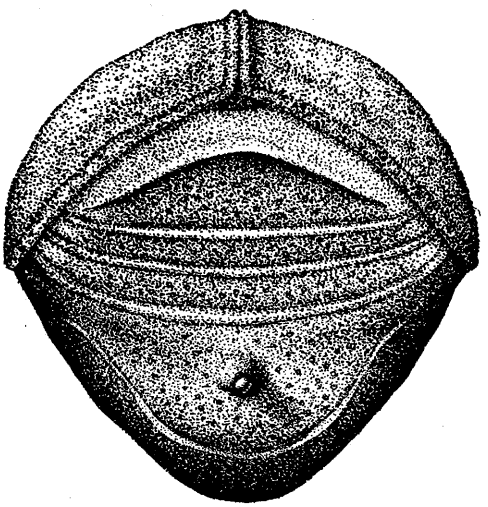

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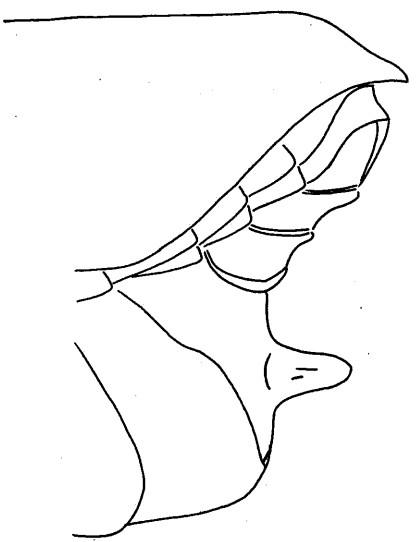

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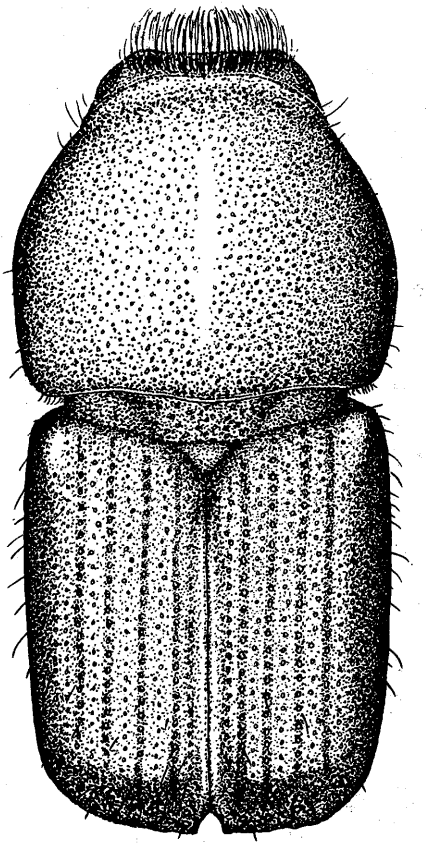
S. laricis



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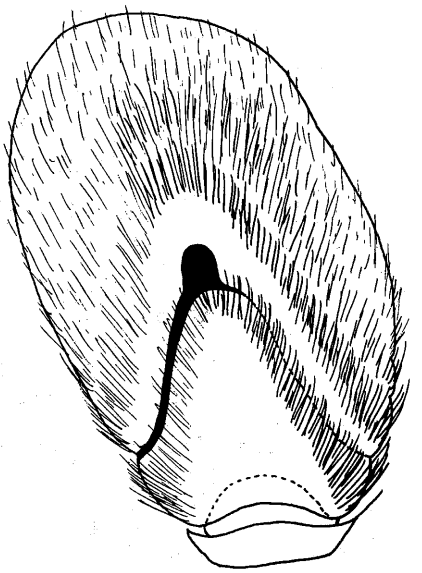

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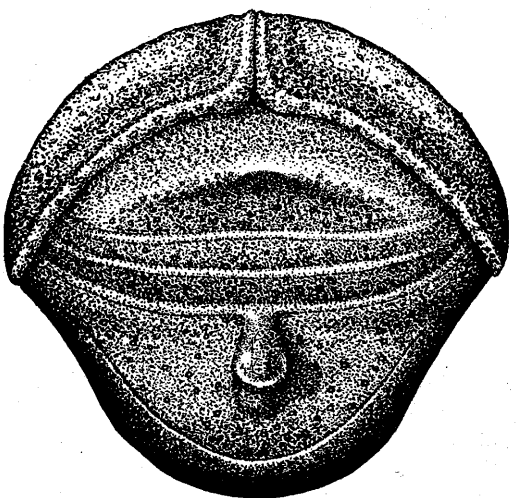

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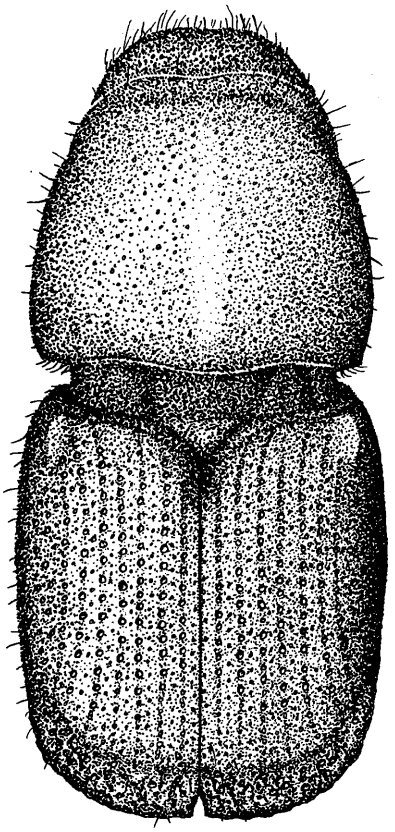
S. unispinosus



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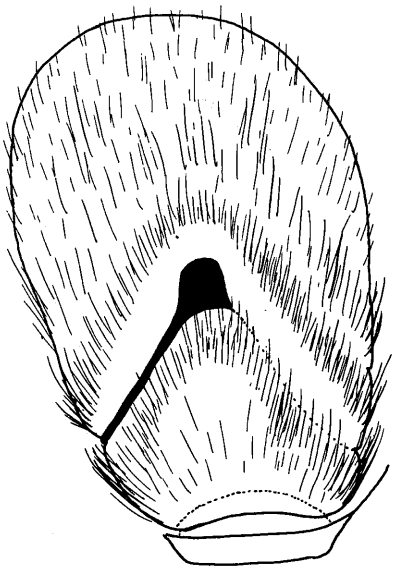

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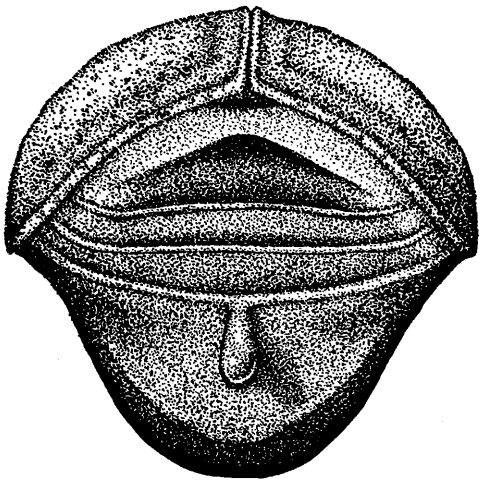

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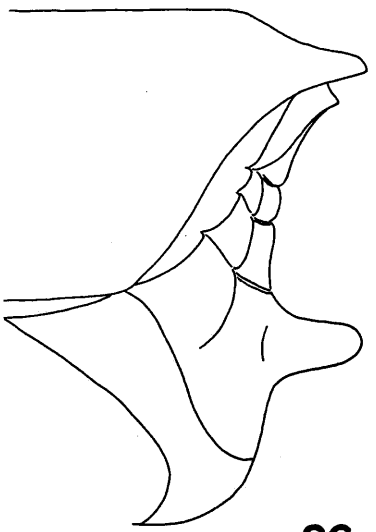

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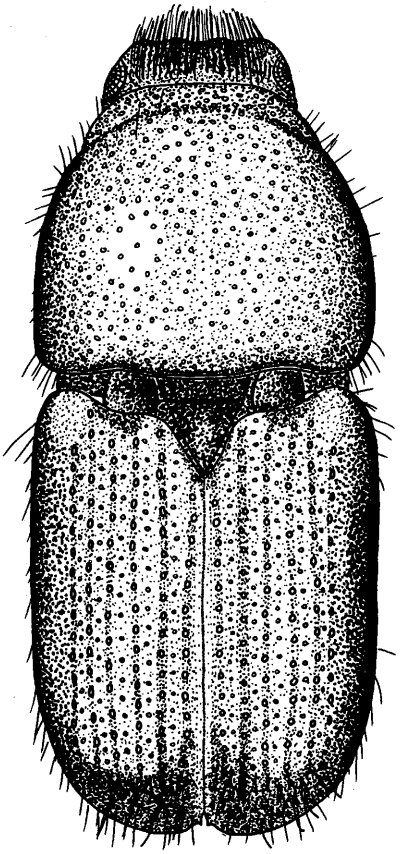
S. fiskei



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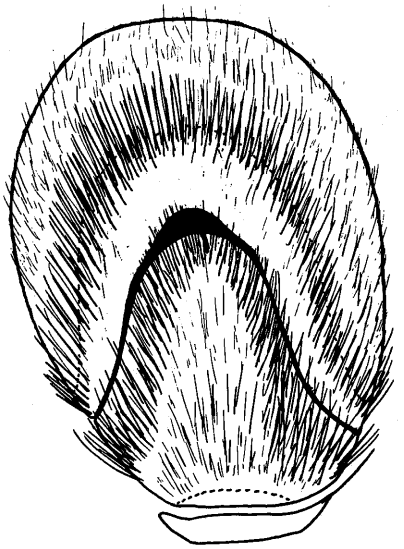

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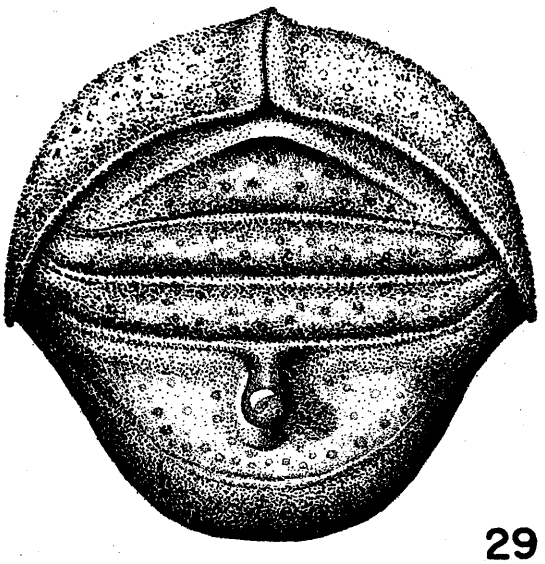

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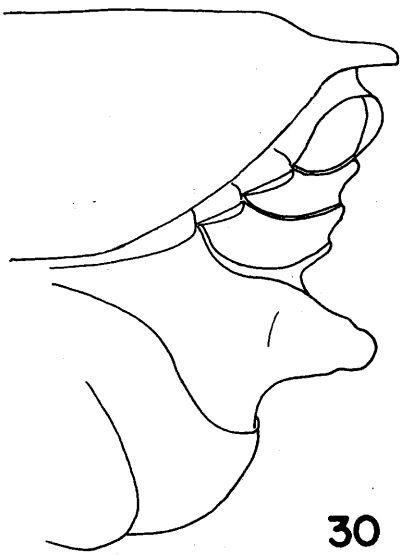

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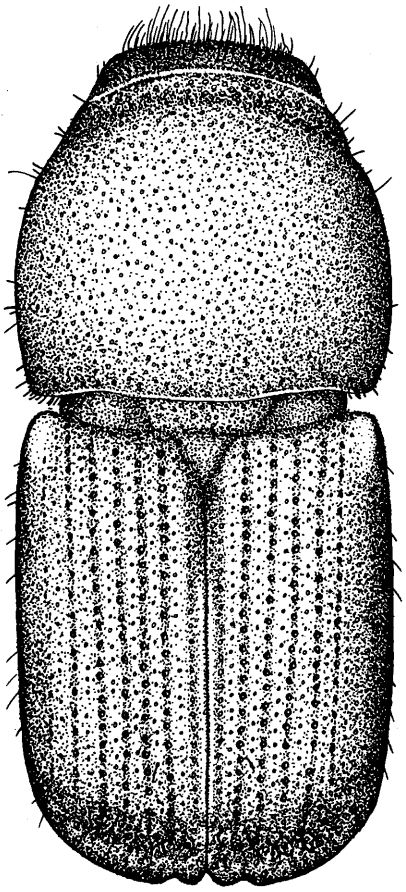
S. wickhami



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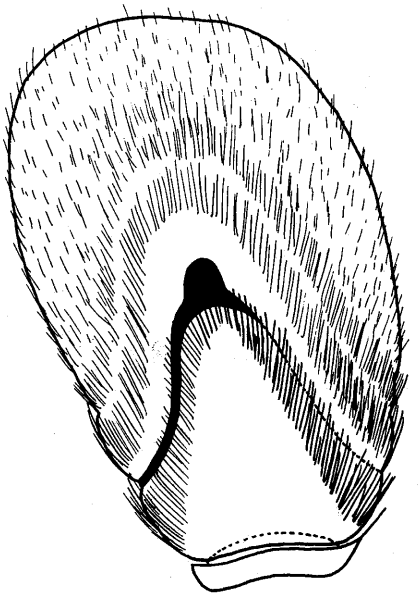

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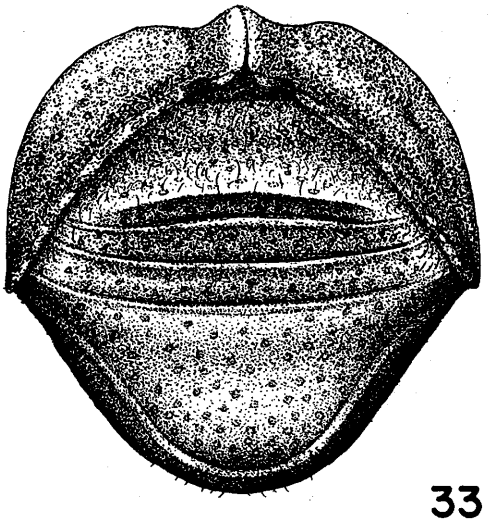

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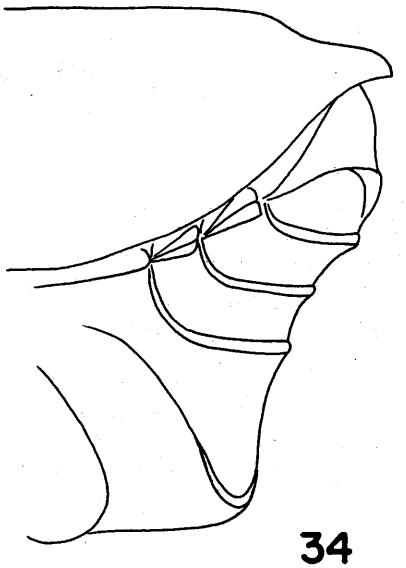

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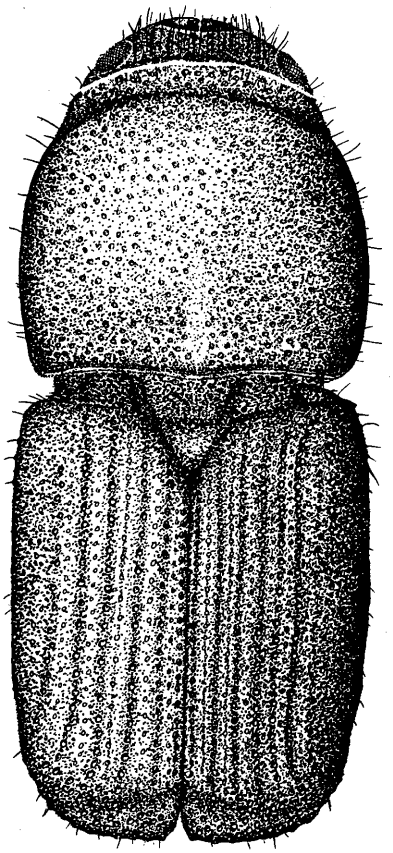
S. tsugae



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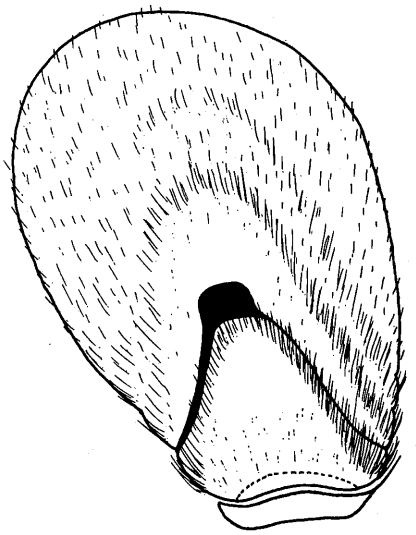

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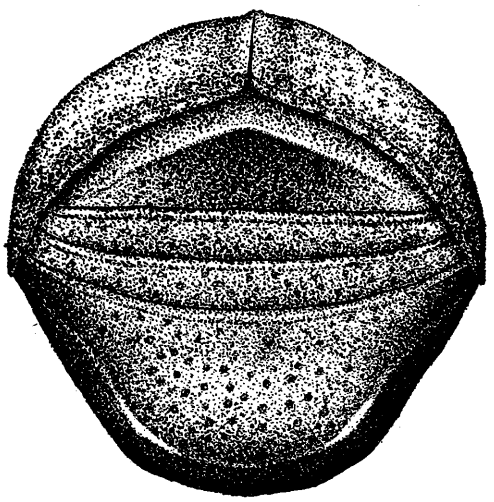

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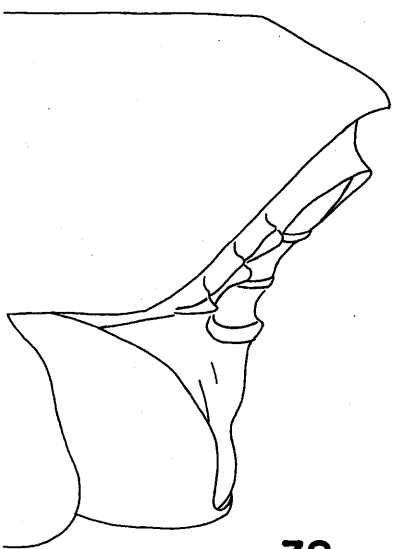

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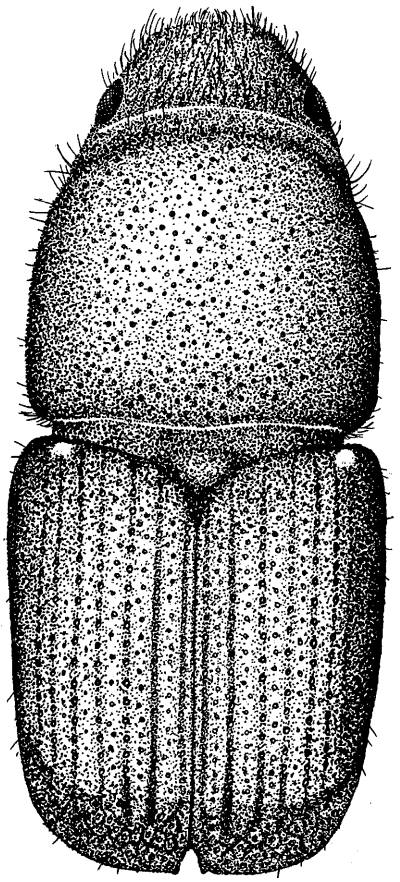
S. monticolae



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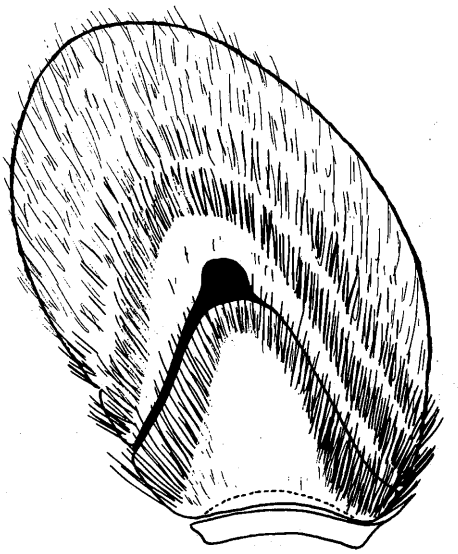

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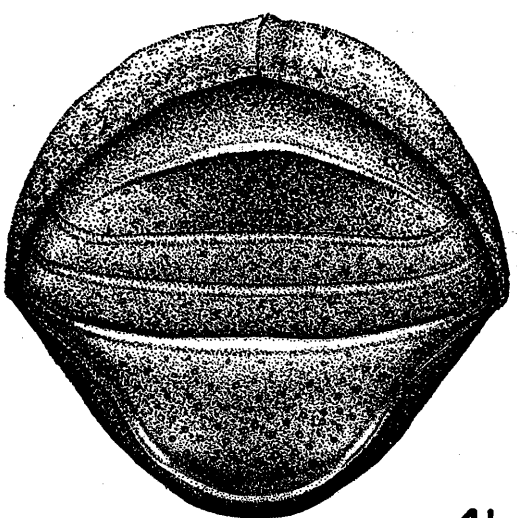

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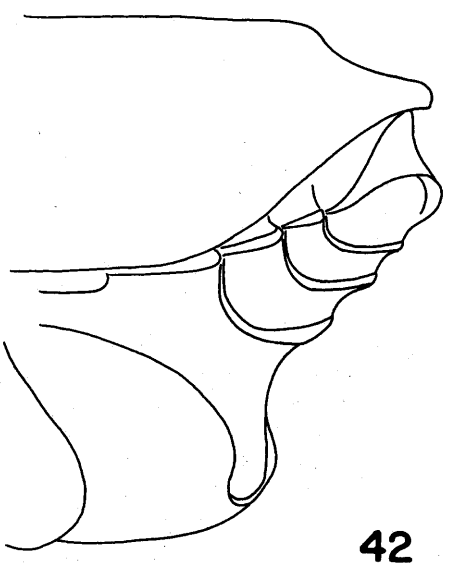

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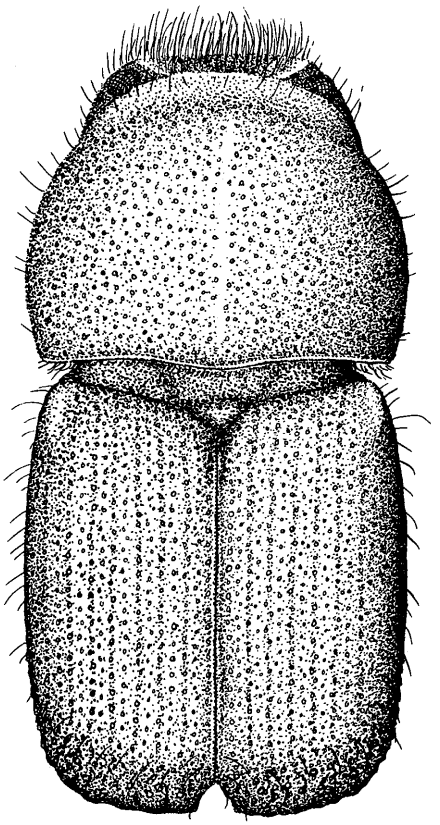
S. oregoni



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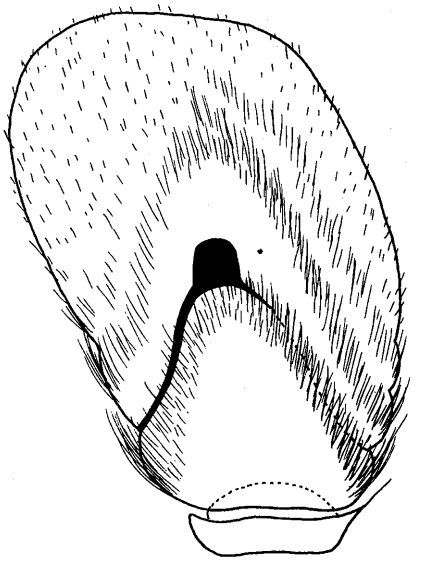

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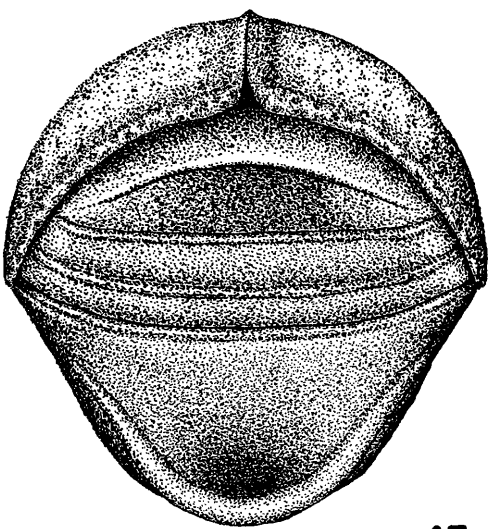

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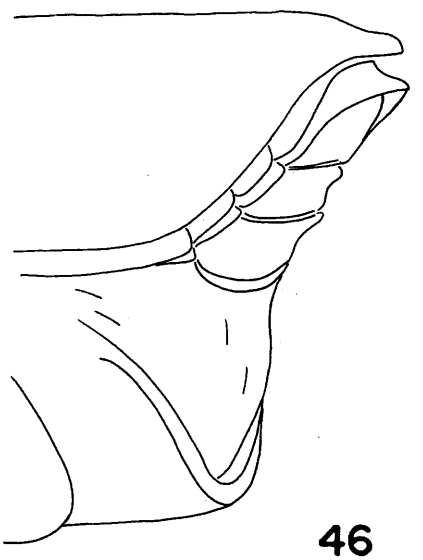

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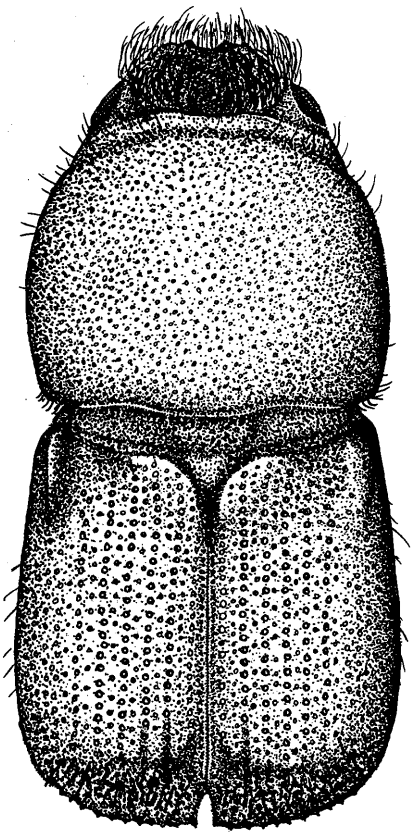
S. robustus



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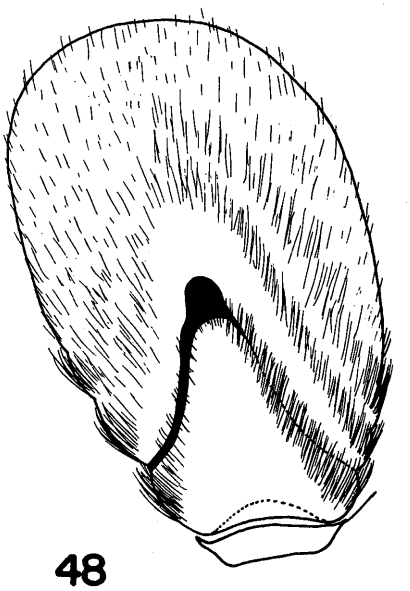

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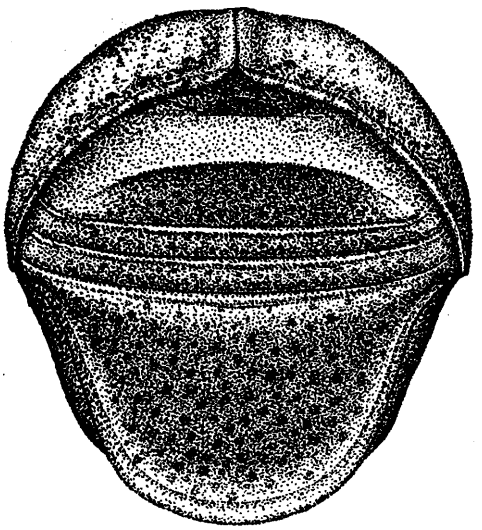

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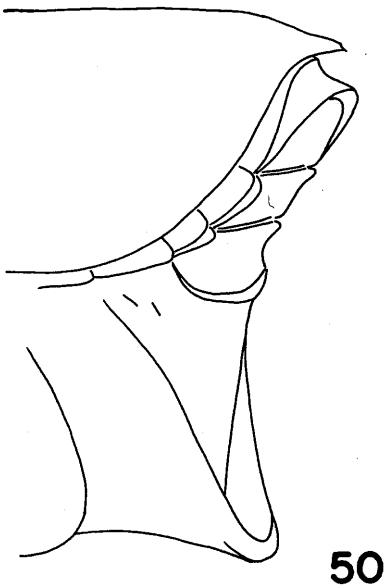

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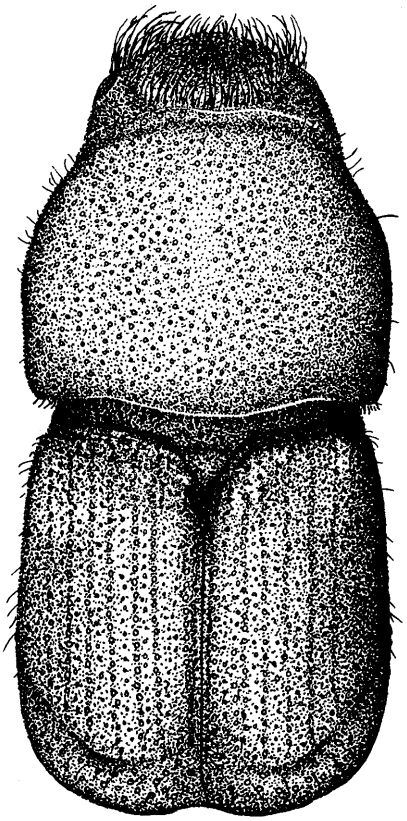

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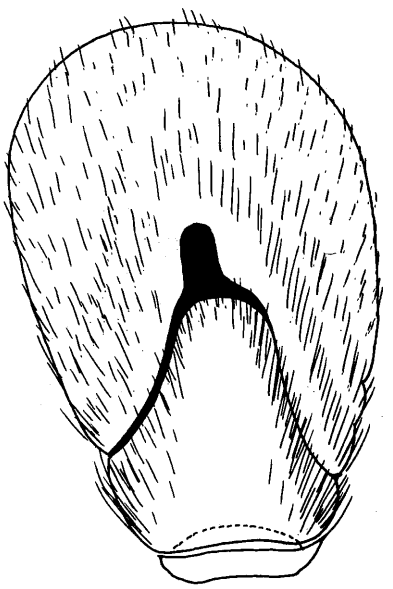

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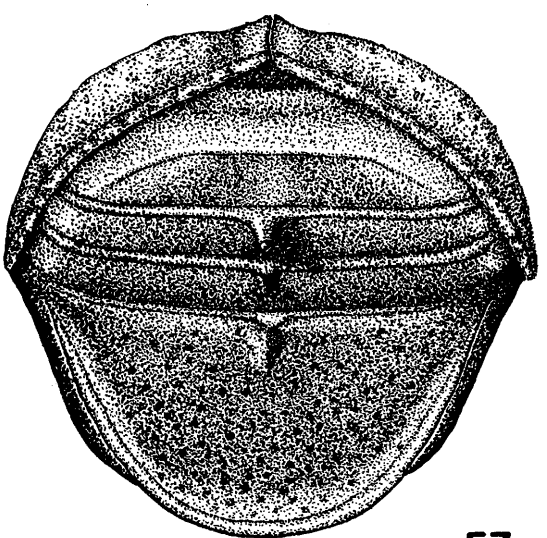

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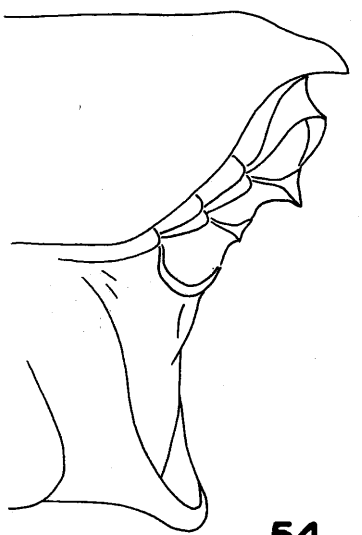

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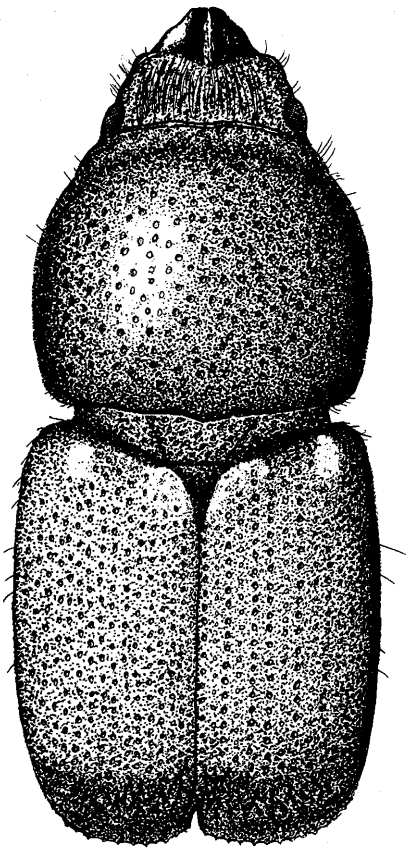

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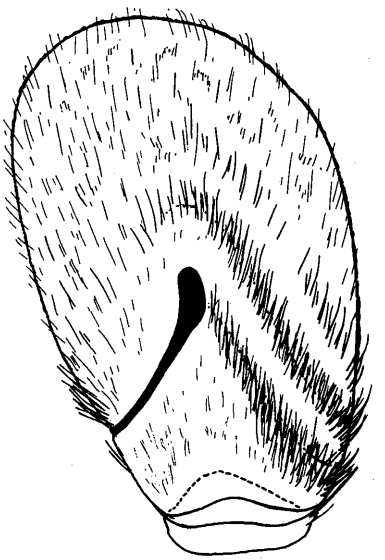

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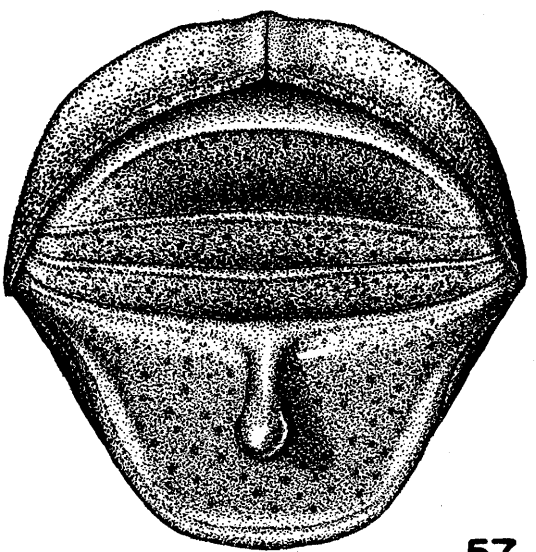

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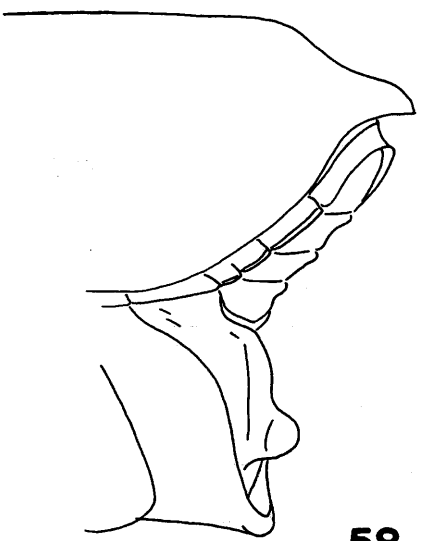

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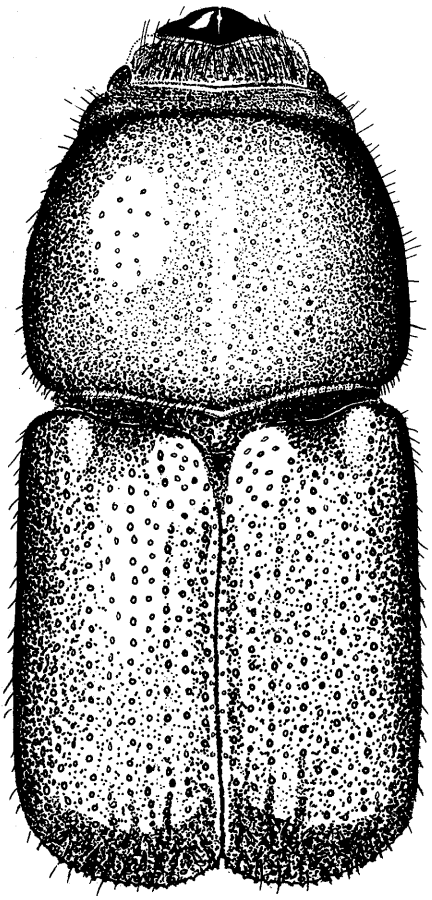

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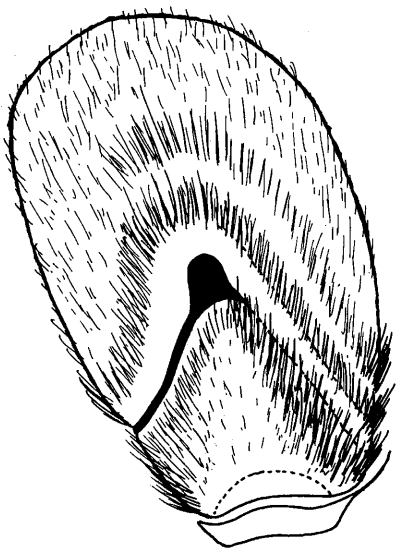

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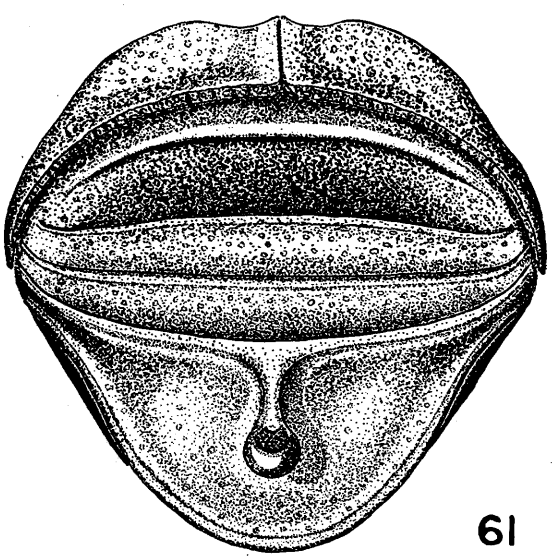

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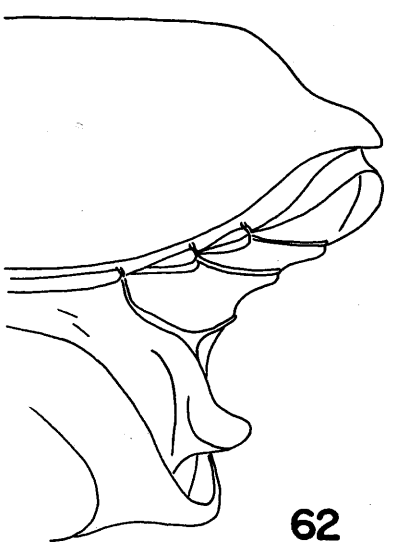

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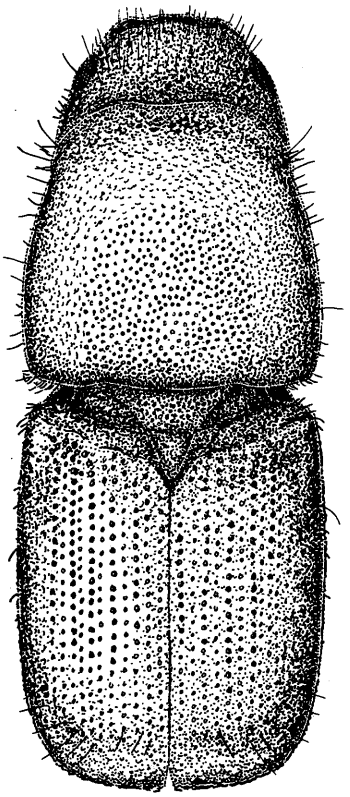

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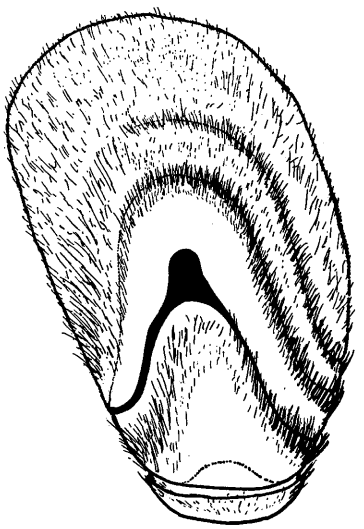

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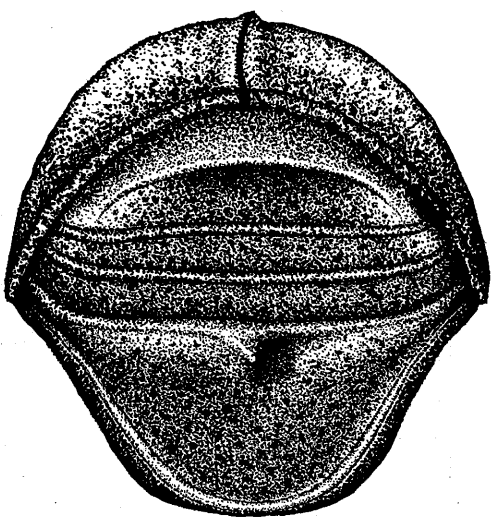

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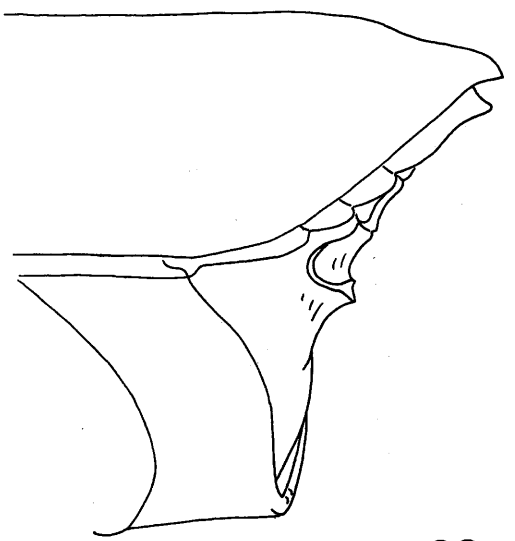

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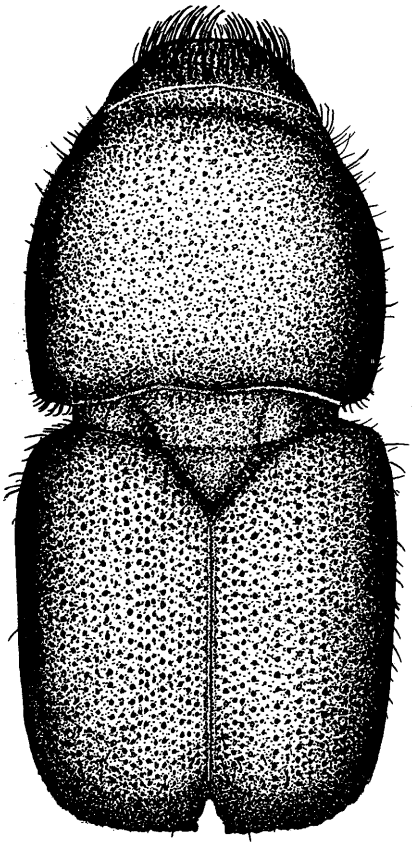
S. subscaber



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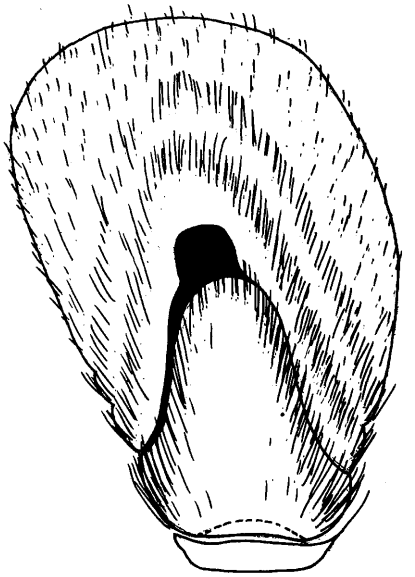

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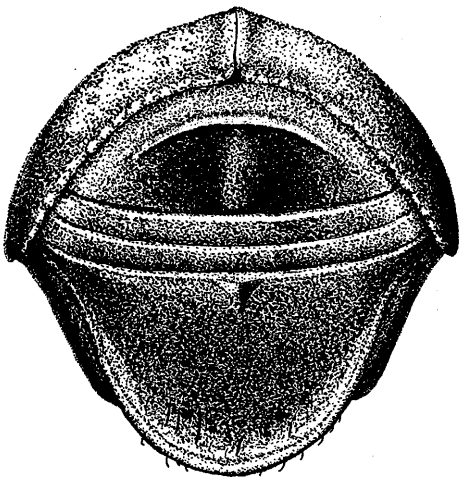

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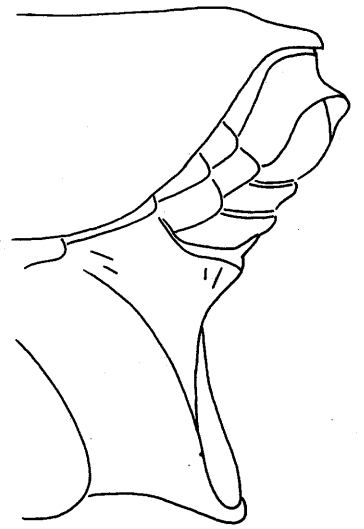

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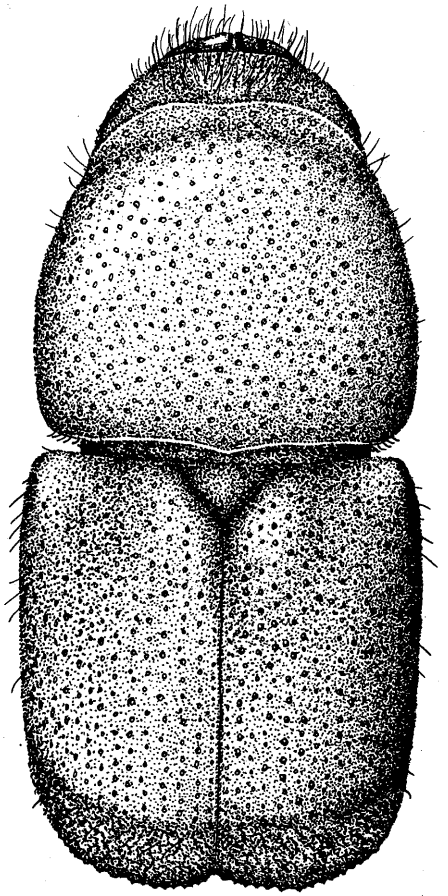

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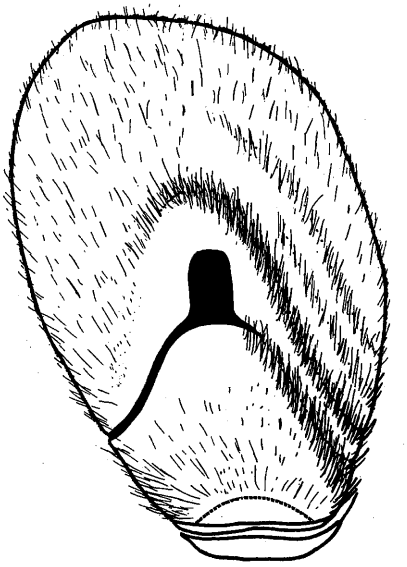

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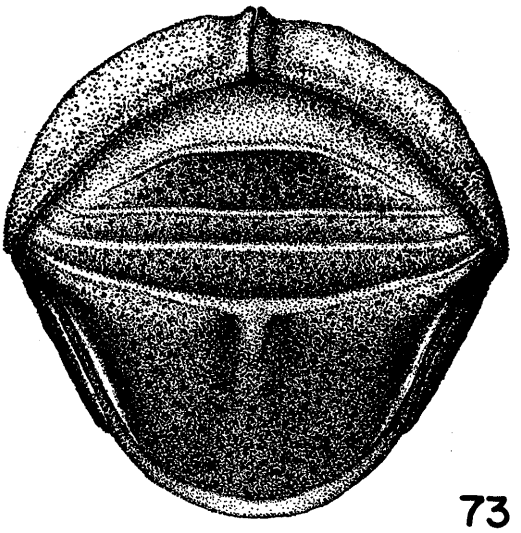

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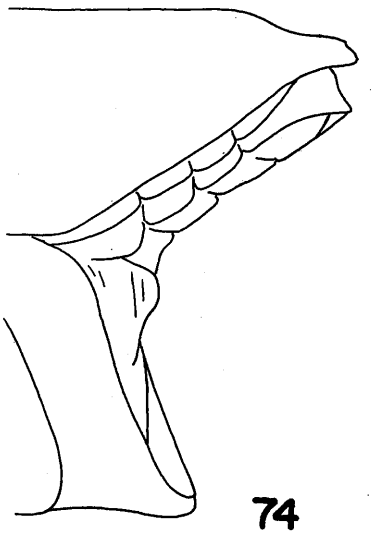

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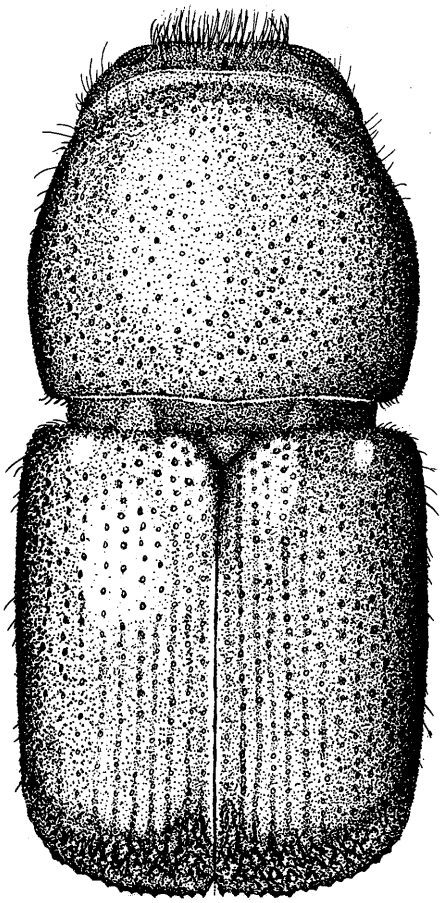

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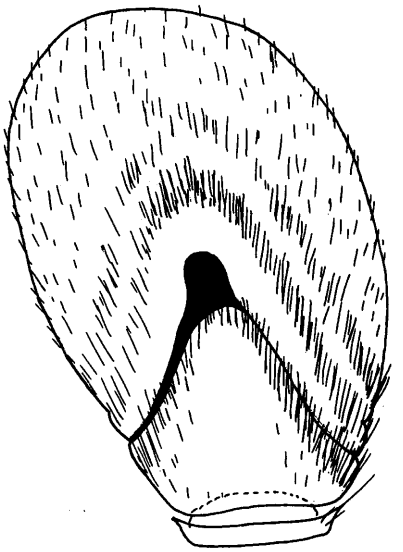

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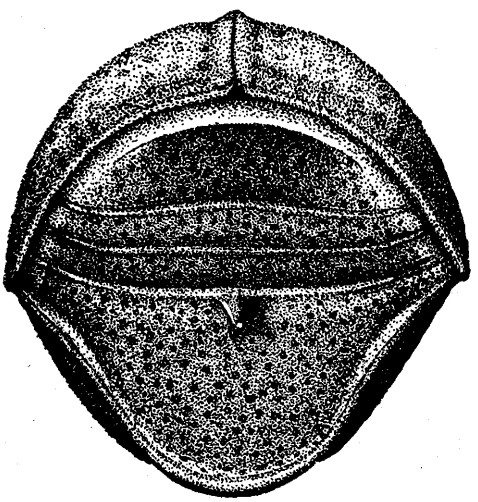

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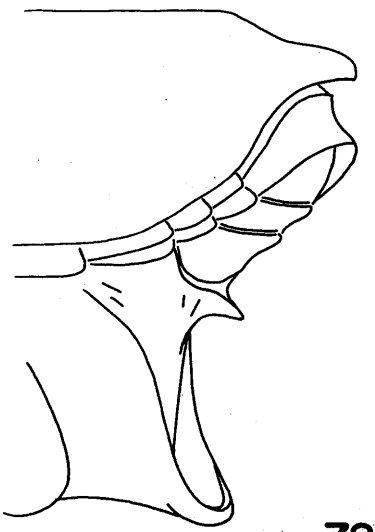

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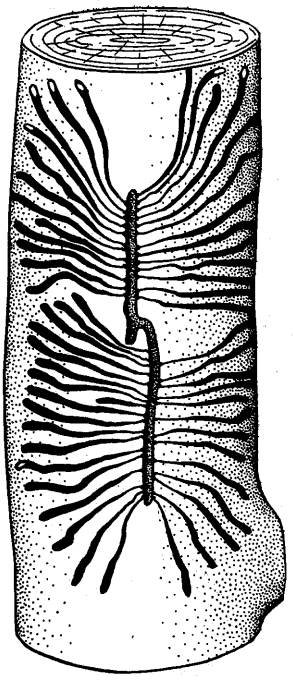

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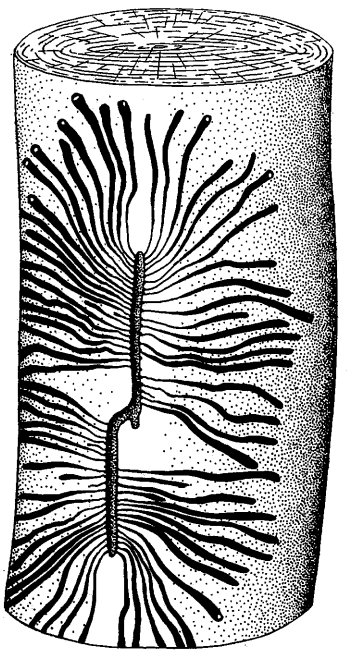

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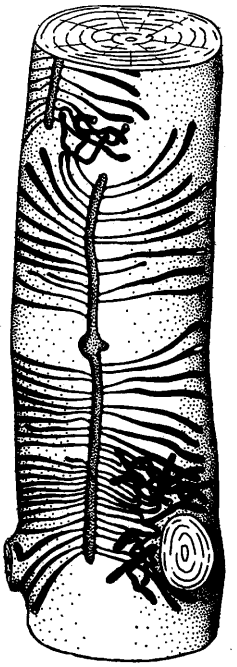

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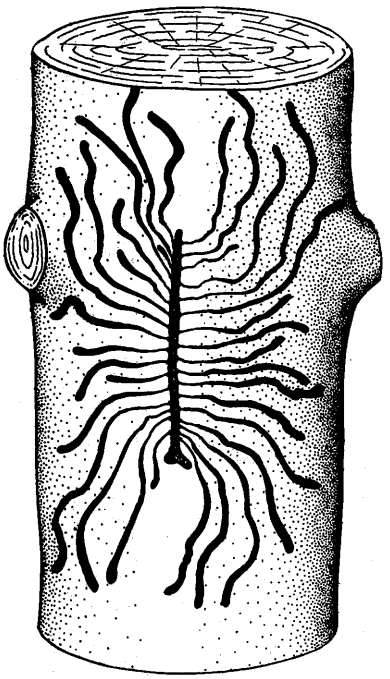

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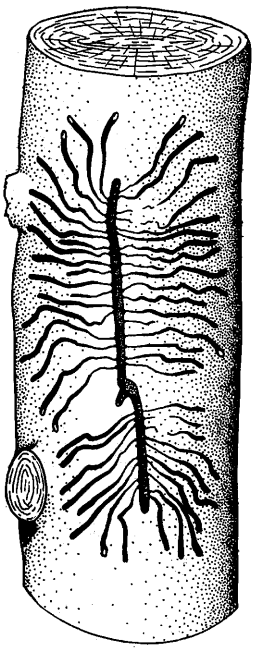

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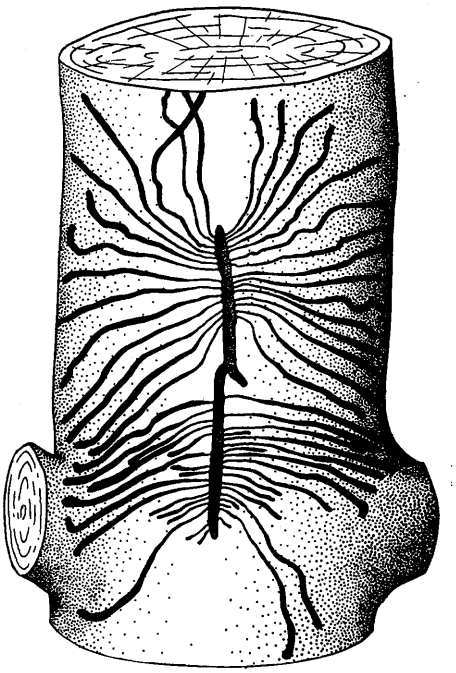

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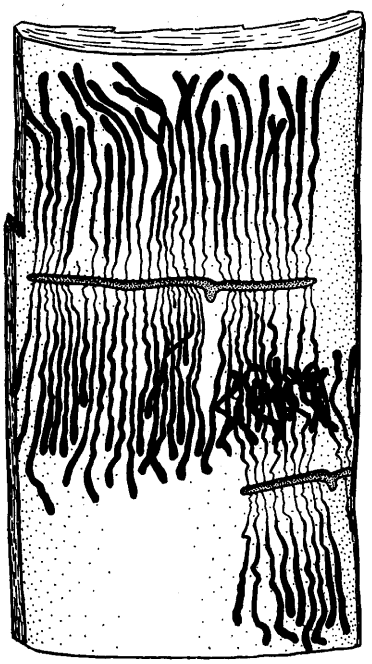

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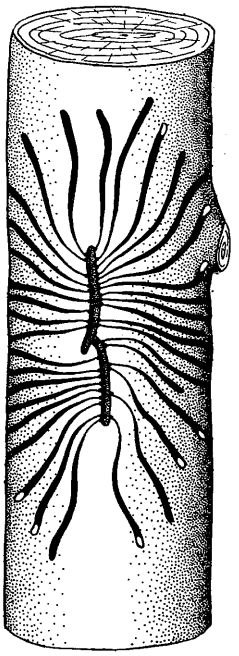

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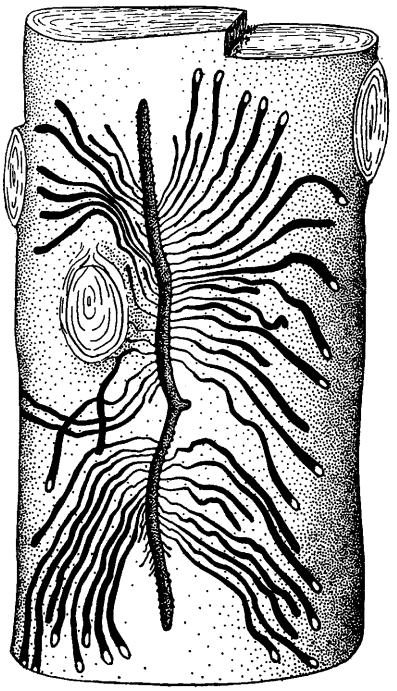

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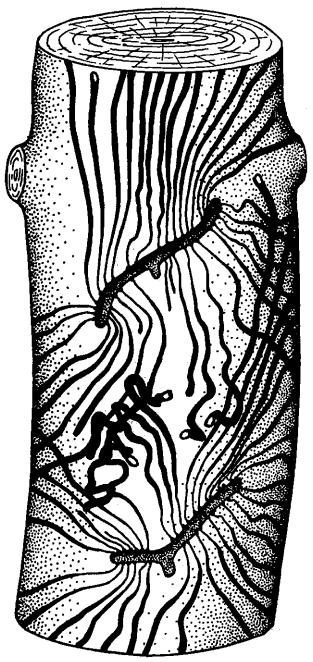
S. oregoni



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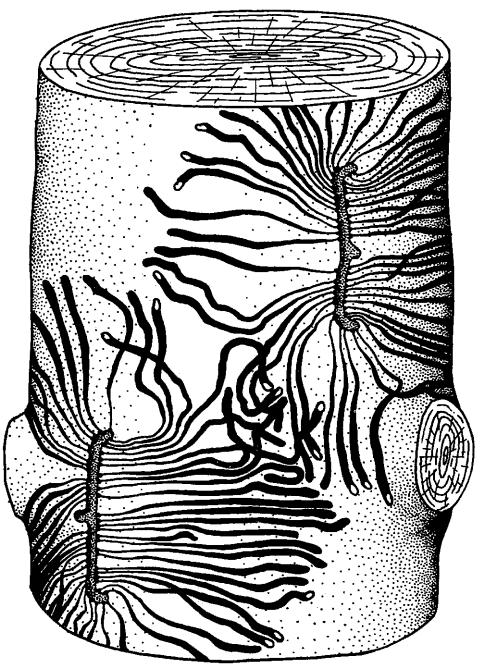

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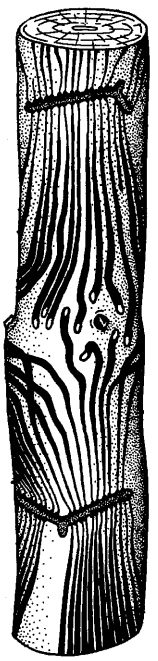
S. dentatus



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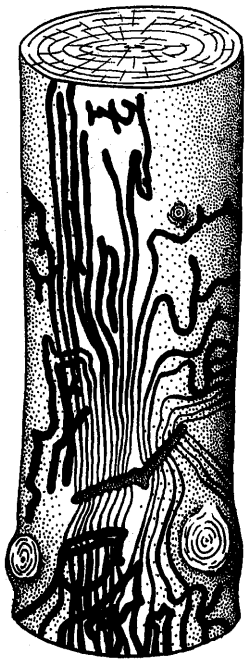

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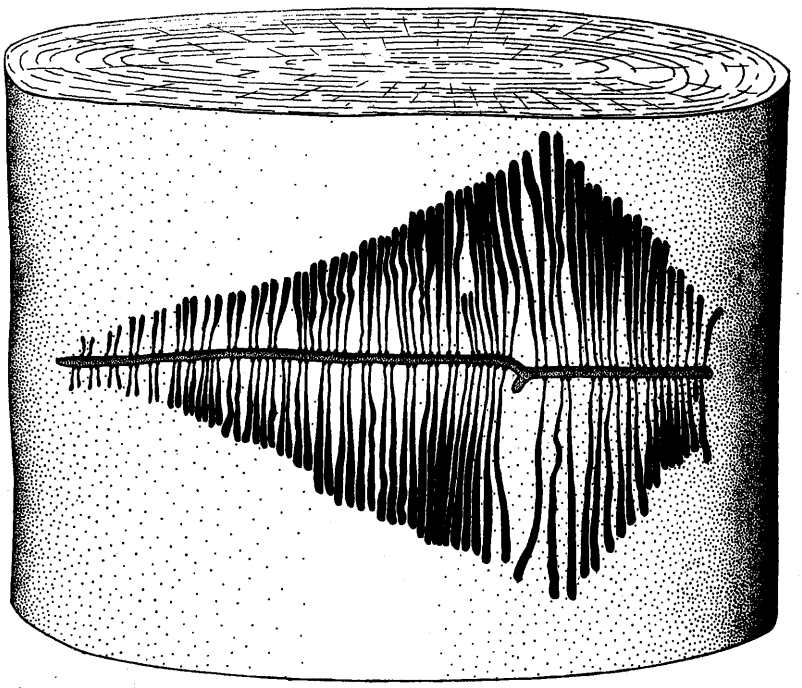

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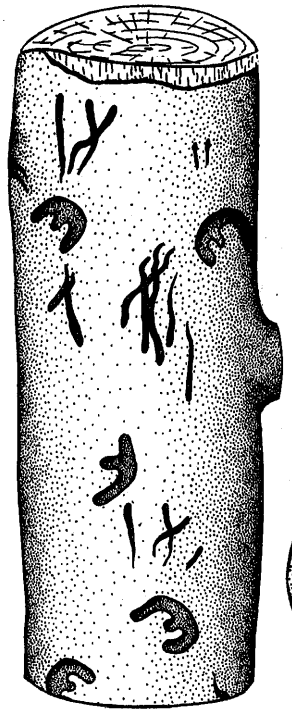
S. ventralis



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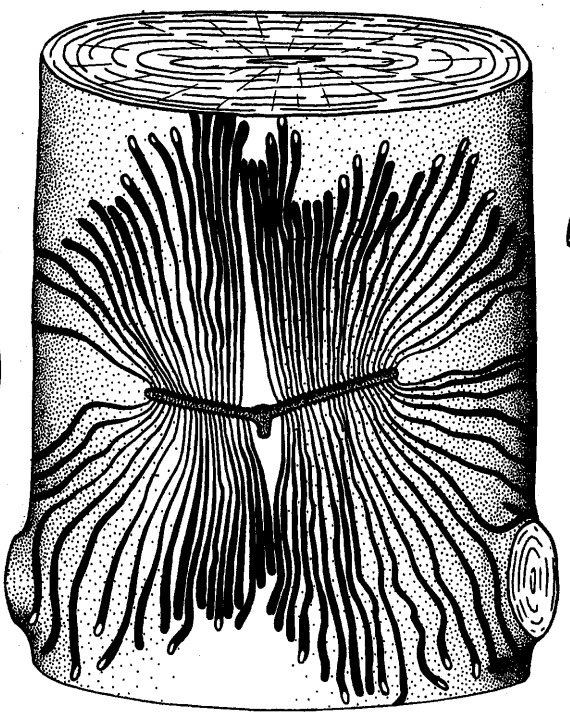
S. subscaber



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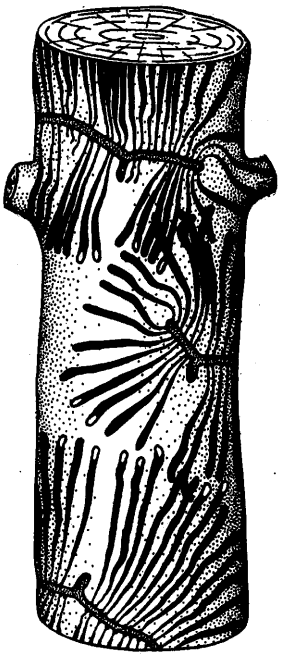
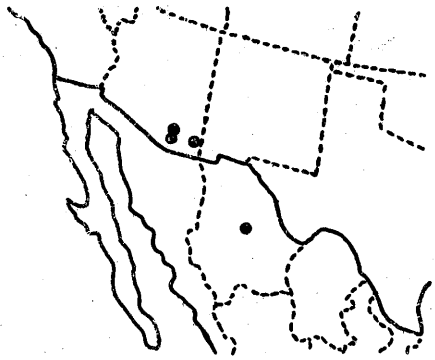
S. praeceps



95

S. obelus



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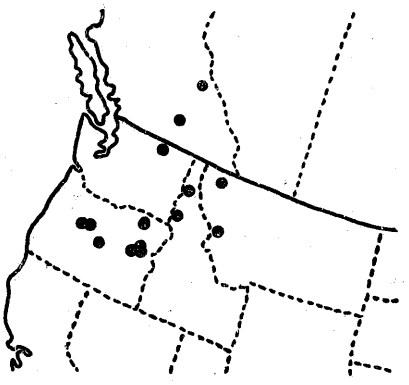
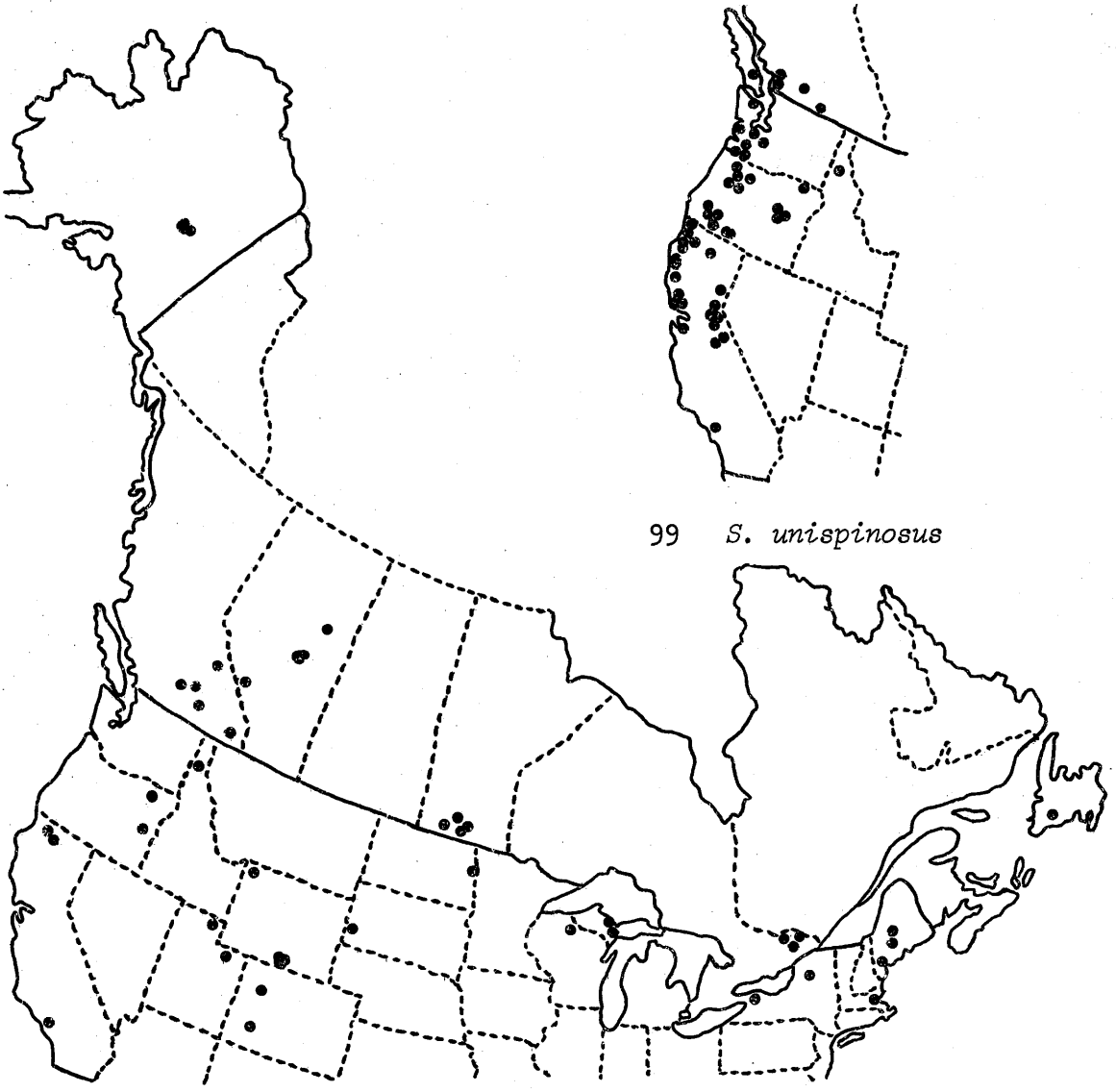


98 *S. laricis*

99 *S. unispinosus*



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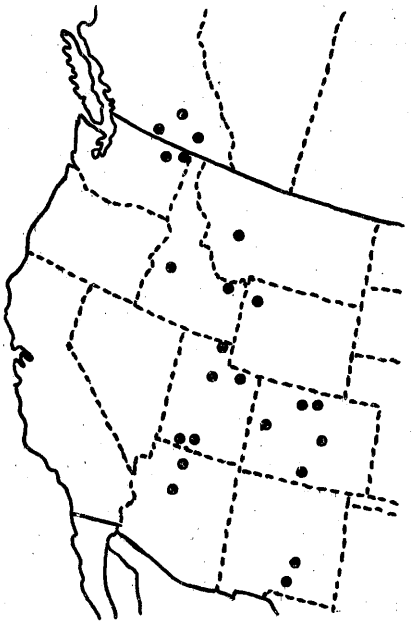

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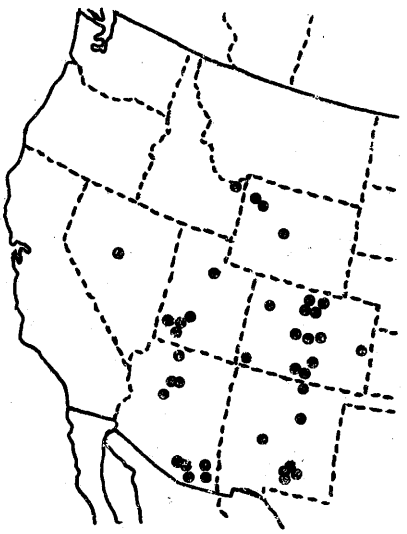
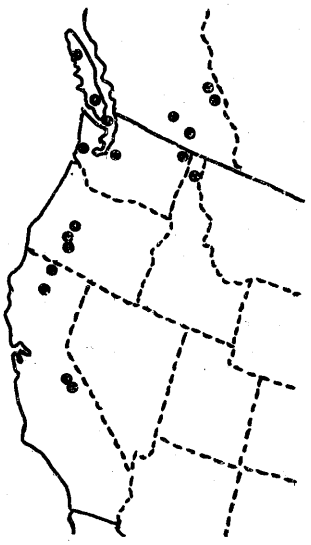


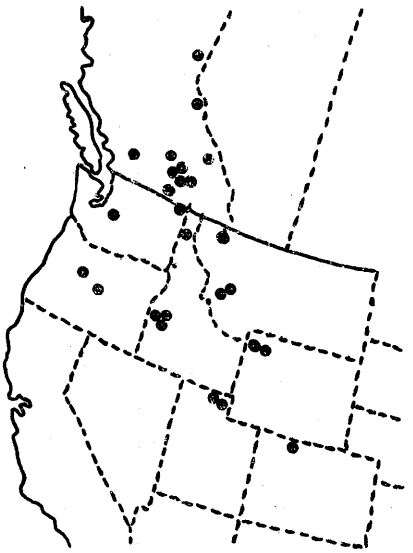
101

S. wickhami



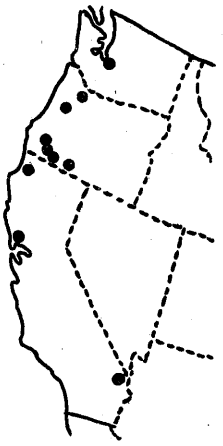
102

S. tsugae

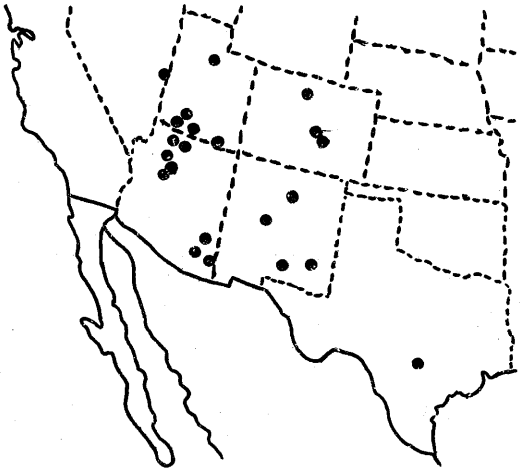


103

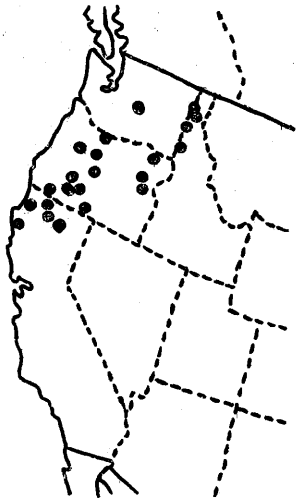
S. monticolae



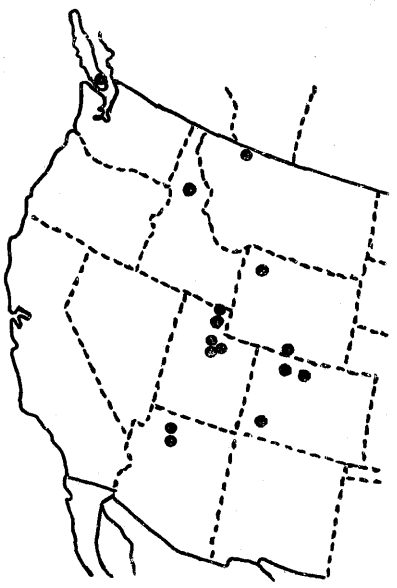
104
S. oregoni



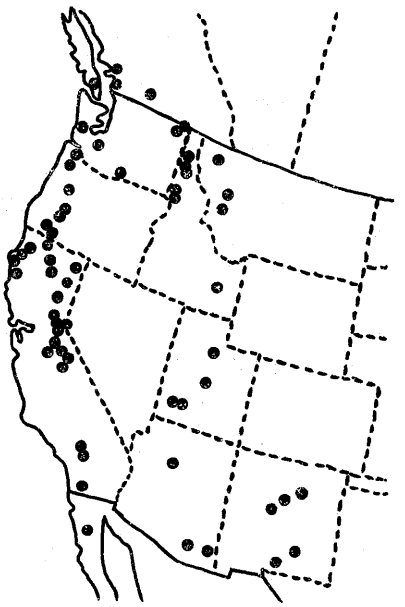
105
S. robustus



106
S. abietis

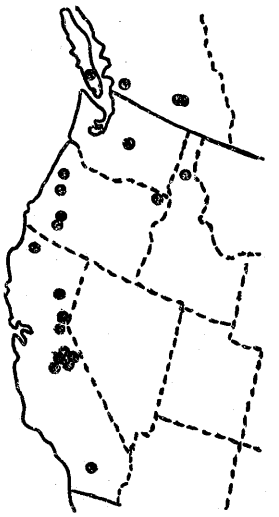


107
S. opacus



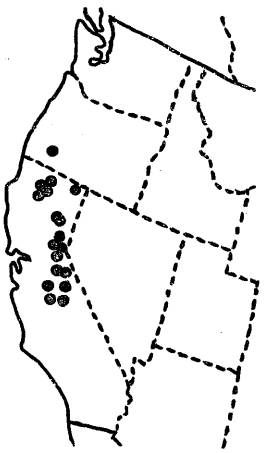
108

S. ventralis



109

S. subscaber



110

S. praeceps

111

S. obelus